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REVIEW OF AVAILABLE LITERATURE ON THE LARYNX FOR 1957.*

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ANATOMY.

Pichler and Gisel,[1] who worked on 100 dissections with a dissecting microscope, caution against accepting the presence of an extralaryngeal motor ramus posterior to the recurrent nerve. They observed that this branch supplied the mucosa and anastomosed with the posterior segment of the superior laryngeal nerve. In their dissections the main nerve branched endolaryngeally, and a definite abductor and adductor branch could not be demonstrated. These observations do not coincide with those of King and Gregg, Rustad or Morris and, therefore, present food for thought, as any definite conclusion at this time would be premature.

In a study of the recurrent laryngeal nerve in cats, Murray[2] noted that the nerve supplying the intrinsic muscles of the larynx in these animals has a unimodal fiber-sized distribution. He was also able to show that there are few or no proprioceptor fibers in this nerve. Probably one of his most interesting observations is that in the recurrent laryngeal nerve there is a variable number of fibers of extravagal origin.

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Caparosa and Zavatsky[3] describe the anatomy of the cricothyroid space, emphasizing the paucity of vessels and vital structures. They recommend this space as a site for emergency tracheotomy in the full sense of the word emergency. Whenever possible, this procedure should be followed by the classical tracheotomy within eight to ten hours to prevent development of stenosis. Complications are listed, and steps to prevent these are described.

Clader and co-authors[4] realized that a detailed knowledge of the surgical anatomy of the superior and inferior laryngeal nerves and their corresponding thyroid arteries is essential for surgeons who undertake surgical procedures upon the thyroid gland. For this reason, they undertook to dissect, study and photograph the thyroid compartment of the anterior portion of the neck of 50 recently embalmed bodies. Their findings are well tabulated, and the photographs clearly show the variations of the inferior laryngeal nerve, which in one case, divided into six branches. Forty-three per cent of the specimens in this series had nerves with from two to six extra laryngeal branches. Their conclusions pointed out that external division of the superior laryngeal nerve is often in danger during ligation of the superior thyroid artery. There is no constant relationship between the inferior thyroid artery and the inferior laryngeal nerve. This is an excellent article for quick review before thyroid surgery.

Gregg[5] undertook a study of the extralaryngeal nerves for the purpose of facilitating recognition of these structures when doing thyroid surgery. Some of the types of vocal cord paralysis produced in dogs help us to understand what may occur in patients undergoing thyroidectomy. Gregg advocates routine dissection of the recurrent laryngeal nerve in all thyroidectomies. Injury to the extralaryngeal nerves with resulting paralysis may be temporary or permanent depending upon factors as yet not explained.

Negus,[6] in his inimitable and thorough way presents an interesting and enlightening article dealing with the history of man from the standpoint of the nose and larynx. The ease of his style and the manner of writing belie the vast amount

of work and energy represented in this concise article. For one who is interested in research or as a reference article this concise manuscript is invaluable.

PHYSIOLOGY.

The Semon lecture on the physiology of phonation was delivered in 1956 by Portmann.[7] In this interesting lecture Portmann discusses at length the myo-elastic, or tonic theory, and the clonic theory; however, there is little unanimity of acceptance of either theory. Those interested in this subject should read his article, which also gives much consideration to the three levels of stimulation: the cortex, the diencephalon and the medulla oblongata.

In order to test a hypothesis on the origin of the vibrations of the vocal folds Van Den Berg and Spoor[8] made some simultaneous recordings on the electromyogram of the thyro-arytenoideus muscle and the sound curve in a patient who had a stoma just above the larynx and whose laryngeal muscles presented themselves directly. Electrodes were placed, one in the thyro-arytenoideus muscle and the other near the arytenoid. The vibrations were in agreement with the results noted by Trendelenburg and Wullstein. Van Den Berg and Spoor state that the microphonic effect of the larynx will manifest itself in all the recordings of the potentials of a large region of the internal laryngeal muscles. They believe that this is the explanation for the synchronism claimed between the potentials in the recurrent nerve and the sound pattern.

In his usual interesting, thorough manner Negus[9] presents a comprehensive article on the mechanism of the larynx, which leaves little to be desired. He begins with the evolution of the larynx from the simple vertebrates to man. In covering the phase of evolution, he describes the physiology and anatomy of various types of animals. One of the important functions of the larynx, little considered, is the assistance in blood and circulation by pump action. The other functions of the larynx are fully discussed. It is concluded that phonation was developed secondarily. Negus emphasizes the point

that when dealing with the production of sound, the larynx of man follows the general physiologic principles applicable to other vertebrates and is not subject to mechanisms of purely human design.

In a discussion of the theory of the nature of the vibrations of the vocal cords, Froeschels[10] states that until recently it was almost the general opinion that the vibrations of the vocal cords are initiated by the stream of air and that the swing back is due to the elasticity of the cords. The function of the recurrent nerves was considered to be the innervation of the muscles that open and close the glottis. The cranial branch of the pneumogastric nerve, according to the theory, innervates the cricothyroid muscle, thus helping to elongate the vocal cords. This is called the myo-elastic or aerodynamic-muscular theory. Husson's neuromuscular theory is new; according to it every vocal vibration is due to a single impulse from the recurrent nerve and not to air pressure. This function of the recurrent nerve is from central stimulation with acoustic center regulating the pitch. Froeschels questions Husson's theory, pointing out that many patients with bilateral abductor paralysis have excellent voices. In some of these the recurrent nerve had been accidentally severed during operation. Froeschels has been unable to accept the facts as described in the Husson theory, but he believes that this interesting theory should be studied further before it can be fully accepted.

Floyd and co-workers[11] report their observations on numerous experiments on the mechanism of phonation. There are two main theories: the tonic and the clonic, and the advocates of each are staunch believers in the validity of their theory. Floyd and associates describe the action of the intrinsic muscles of the larynx on the function of the vocal cords. They conclude that they do not agree that clonic contraction of the intrinsic muscles of the larynx is possible at rates above 110 C/S, and in consequence they give their full support to the older tonic theory.

Van den Berg[12] reports that Piquet and associates took some high-speed motion pictures of the vibrations of the vocal folds

during total laryngectomy without an air stream through the glottis. Certain observations were recorded pertinent to the cause of vibrations of the vocal cords. Their conclusions play a role in the current discussion of the myo-elastic and neuro-chronaxic theories of voice production. Van den Berg discusses these at length and believes that Piquet and associates' attempts to prevent a flow of air through the glottis were unsucessful.

ABNORMALITIES.

Alonso and Regules[13] describe a simple procedure for treatment of congenital and cicatricial webs in the anterior portion of the larynx in children and adults. They briefly review the methods now being used for amelioration or correction of the existing conditions and then describe their method, which consists of removing the web through a laryngoscope and then placing a thin polyethylene semi-circular plate with nylon thread attached to the straight edge of the plate. The two ends of the nylon thread are introduced through the mouth into the larynx and brought out through the thyrohyoid and cricothyroid membranes; by this means the polyethylene plate is placed in the anterior portion of the larynx. This plate is held in place by tying the nylon thread over rubber tubing. The authors used this procedure only one year and, therefore, they have not performed it on many patients. The procedure has much merit and will be used by many laryngologists in the due course of time.

Respiratory distress in dogs may result from a number of causes. Leonard[14] reports five cases of eversion of the lateral ventricles of the larynx responsible for respiratory distress. In three of these dogs the protruding ventricles were removed with a tonsil snare. All recovered and were free from respiratory distress.

DIAGNOSIS.

In an article on the radiologic investigation of diseases of the ear, nose and throat, Samuel[15] states that radiologic examination of the larynx cannot be regarded as complete un-

til the cervical esophagus has been filled with barium and its outlines demonstrated. He describes the technique used in obtaining these radiographs and extols the merits of films of good quality. Malignant growths of the larynx will obliterate normal workings. The lateral view is of great value in assessing subglottic extension of such neoplasms.

Pirozok and associates[16] propose a method for rapid histologic diagnosis of infectious avian laryngotracheitis. All agree that this infection is highly contagious and fatal. Gross pathologic examination usually yields inconclusive results and other diagnostic methods are time-consuming. The method of obtaining reliable histologic sections mounted on slides described by Pirozok and associates requires three hours. They use Carbowax$^{W®}$ as an embedding medium for sectioning tracheas in the differential diagnosis of laryngotracheitis.

Powers and co-workers[17] present the results of their anatomic study of the larynx in which they used a contrast medium to obtain radiographs. Experiments proved that use of Dionosil,® introduced slowly into the hypopharynx and larynx after topical anesthetization, offered the best results for interpretation of existing disease, and functional and anatomic abnormalities.

INSTRUMENTS.

Martin[18] presents a new type of pharyngolaryngoscope with a wide proximal end tapering to the distal end and containing an electric bulb for proper illumination. The wide proximal end permits binocular vision of the base of the tongue and vocal cords. There are three sets of tapered tubes that fit on one handle. The instrument is best employed with use of a general anesthetic, as Martin says it is not always practical to use a topical anesthetic.

Pitman[19] presents a new instrument for examination of the larynx of patients having extremely sensitive throats and anatomic difficulties. This instrument, modeled after the pattern of a nasopharyngoscope, is called by Pitman a *nasolaryngoscope*. It is introduced through one nostril after proper cocainization of the nose; by means of proper lenses,

prisms and light, it is possible to obtain a view of the larynx when the tip of the instrument is placed through the nostril into the nasopharynx, and the illumination is directed downward for visualization of the larynx.

The tubular portion of the Jackson laryngoscope has been modified by Heinberg,[20] so that it is no longer a closed tube as in Jackson's instrument. The modification consists of an opening about one-half inch wide along the tubular wall whereby such things as instruments and suction tubes may readily be passed in or out of the laryngoscope.

DISEASES.

In an excellent article, Jones and Camps[21] report results of a study of 29 cases of acute epiglottitis. The clinical picture is well described. The diagnosis is suspected by recognition of upper respiratory obstruction and is confirmed by the appearance of the epiglottis. Early recognition and immediate hospitalization are most important. The treatment "par excellence" is tracheotomy. The specific infecting organism in their patients was the hemophilus influenza, Type B, which responded favorably to treatment with chlortetracycline, the drug of choice for this condition.

In a brief, uninformative article Chia[22] reports a case of a patient having two diseases simultaneously. He believed that the patient suffered from tuberculosis of the cervical glands and larynx, and from an osteogenic sarcoma of the tibia with a secondary deposit in the first rib.

Heinberg[23] states that many changes in the concept of laryngeal obstruction in children have occurred during the past three decades. The medical profession has realized that infections other than diphtheria can cause obstruction of the airway. Chemotherapy and the antibiotics have resulted in management of these cases by the family physician or pediatrician; however, when the laryngitis becomes obstructive, the laryngologist is called. Heinberg pleads for early teamwork to prevent anoxia and toxemia. He discusses the various causes of laryngeal obstructiton and outlines the therapy.

Contact ulcer has been attributed to excessive use of the voice and exposure to irritants. Ulcers due to emotional strain have been reported. Rubenstein[24] presents such a case of an ulcer that persisted for many years despite all methods of surgical and medical treatment. Finally, the conditions producing the severe emotional strain were removed, and immediately the ulcer healed spontaneously.

In a brief but interesting article Pearson[25] describes a case of rheumatoid arthritis of the larynx in a 61-year-old man who had had rheumatoid arthritis for more than 30 years. Dyspnea, due to limited abduction on respiration, developed necessitating tracheotomy. Death was due to respiratory infection and consolidation. Histologic sections of the larynx showed changes in the crico-arytenoid joints characteristic of rheumatoid arthritis. If laryngeal stridor occurs in a case of rheumatoid arthritis, the most likely cause is involvement of the crico-arytenoid joints by the pathologic process.

In discussing rheumatoid arthritis of the crico-arytenoid joints, Copeman[26] states that it is strange that no article in the English language appears to have been written on this subject. He describes the crico-arytenoid joints in minute detail. The outstanding symptom besides partial or total ankylosis of the joint is local tenderness on pressure over the larynx between the thyroid and cricoid cartilages laterally or centrally. Copeman reports in detail three cases of rheumatoid arthritis of the larynx. He states that the differential diagnosis in these types of cases appears to lie only between rheumatoid arthritis involving the crico-arytenoid joints and paralysis of the recurrent laryngeal nerves.

Baker and Bywaters[27] report a case of laryngeal stridor in rheumatoid arthritis due to involvement of the crico-arytenoid joint. Classical rheumatoid arthritis had exisited for four years. Dyspnea and dysphagia gradually developed. The left cord became fixed in a position of adduction and the right cord showed progressive loss of abduction. The patient responded favorably to Cortisone therapy. The authors stated that in retrospect the laryngeal picture resembled that of bilateral abductor paralysis.

Muñoz MacCormick[28] discusses the three distinct types of leprosy, namely, the lepromatous, the tuberculoid and the indeterminate from the standpoint of pathology and clinical manifestations. Lesions involve the mucous membranes, especially the nose, in 90 per cent of cases. In the lepromatous or malignant type, the larynx is involved in 28 per cent of cases. The laryngeal pathology is discussed, and the differential diagnosis between this disease, tuberculosis and syphilis is discussed. Lastly, the known treatment is briefly considered with emphasis on investigative studies of drugs like isonicotinic acid and corticotropin. This is a most interesting and thorough discussion of this seldom seen disease in this country.

Obregon[29] reminds us that pemphigus of the larynx, although rare, is of great importance to the laryngologist, because the larynx may be the first site of the disease. He considers four main types: foliaceus, erythematosus, vegetans and vulgaris. He concludes that pemphigus vulgaris is the type most frequently found in the larynx and reports two such cases. Use of the Tzanck or Cantharides tests confirmed the diagnosis. Corticosteroid therapy gave excellent results in both cases.

Coleman[30] calls attention to the fact that apparently benign dysphagia associated with chronic hypochromic anemia in what is commonly known as the Plummer-Vinson syndrome must be regarded as a precancerous state, as it may progress to post-cricoid carcinoma. The syndrome is almost exclusively confined to women. Coleman reports the unusual case of a man in whom hypochromic anemia developed after partial gastrectomy. The syndrome progressed to post-cricoid carcinoma, which is fairly common in women but hitherto unrecorded in a man.

In a most interesting article Silcox[31] describes the powerful effect of corticosteroids in otolaryngological conditions. Its anti-inflammatory action is fully discussed as well as its action on connective tissue permeability. Use of corticosteroids for brief periods is reported as beneficial in acute edema of the larynx, contact ulcers and laryngeal polyps. Silcox stresses

the fact that corticosteroid therapy alone is never curative and always potentially dangerous.

DIVERTICULA.

According to Walls,[32] the diagnosis of laryngocele presents no difficulty provided the condition is kept in mind, since the lesion is rare. The various types of laryngocele are described. The symptoms will depend upon the extent of development and the location of the dilatation. Usually the tumor enlarges when the intraglottic air pressure is increased. Walls reports a case of bilateral laryngoceles of considerable size which were surgically removed with excellent results. In his bibliography Walls fails to mention Felix LeBorgne of Montevideo, who presents many roentgenograms of laryngoceles in his excellent book on radiography of the larynx.

Kodicek[33] reports a case of bilateral external laryngoceles in a man 77 years of age who had been blown up by a shell during the first World War. His voice was extremely hoarse, and the large bilateral swelling in his neck was a source of much interest to his friends. Palpation of the neck during quiet respiration revealed no abnormality. When he was asked to phonate, an air-filled cyst appeared on each side of his neck in front of the sternocleido-mastoid muscle and extended from just below the angle of the lower jaw to about the level of the cricoid. Kodicek describes three types of laryngocele and presents a diagram outlining these cysts. He points out that these cysts of the laryngeal ventricle and saccule show great similarity to the ventricular air sacs present in some monkeys and apes.

Price and associates[34] review briefly the early history of laryngoceles and the anatomy of this region. The etiology, diagnosis and complications are discussed briefly, and the surgical technique for extirpation of a laryngocele is described in detail. Two cases of successful operation are reported.

PARALYSIS.

Sometimes in hemiparalysis of the vocal cord an extreme lateral position of the cord is assumed. Goodyear and Hogg[35]

transplanted a section of cartilage from the superior border of the thyroid cartilage to correct this condition. This was inserted the length of the cord after the cord had been elevated following thyrotomy. When the patient was seen 21 days later, her voice was satisfactory and she was to return to work as a telephone operator the next day.

Reaves[36] states that the main factor in the differential diagnosis of bilateral abductor paralysis of the larynx and bilateral crico-arytenoid ankylosis is the fact that mirror laryngoscopy shows typical bowing of the anterior two-thirds of the cords on inspiration. The basic facts to be kept in mind are that in one there is permanent loss of muscle function, and in the other the laryngeal muscles are temporarily impaired in their action owing to immobile arytenoids. Reaves advocates bilateral arytenoidectomy for correction of bilateral crico-arytenoid ankylosis.

Neurologic complications have been described after injections of such antisera as tetanus, gas gangrene, diphtheria, pneumococcus, streptococcus, typhoid and rabies. The site of injection appears to be unimportant. Radiculitis affecting the fifth and sixth cervical roots is the most common anatomic site of neurologic complications of prophylactic inoculations. Bauer and Ellis[37] report a most interesting case in which a 31-year-old man received antitetanus serum into the right arm because of a cut on a finger. One week later development of neurologic symptoms necessitated hospitalization. Later paralysis of the right vocal cord developed, but four months later it spontaneously subsided. Bauer and Ellis concluded that the paralysis of the recurrent laryngeal nerve was undoubtedly a part of a generalized disease, and they express the hope that for prevention of tetanus, active immunization in the form of toxoid be used in preference to passive immunization by antitoxin, as it is less likely to cause neurologic complications.

In a most excellent, interesting article Arnold[38] presents the current concept of laryngeal paralysis. He prefaces his paper with the statement that whereas the advent of new drugs or bacteriologic advances have radically altered most

aspects of medical practice, the problems of normal and diseased laryngeal innervation remain the same. Arnold attempts to define the major problems of laryngeal paralysis by analyzing the representative bibliography from the following viewpoints: value of animal experiments, chronologic changes in the concepts of laryngeal disease, discussion of central pathways and the peripheral course of the laryngeal nerves, variability of terminal ramification of the recurrent nerves and the present interpretation of the position of the paralyzed cords. Semon's law is discussed at great length, and numerous opinions are quoted. The conclusion reached is that Semon's rule of the greater vulnerability of the abductor fibers represents a clinical observation that signifies either an incipient sign of a progressive lesion or a terminal sign of subsiding paralysis.

Melampi[39] presents a brief review of the occurrence of laryngoplegias in pseudobulbar paralysis, labioglossopharyngeal paralysis, multiple sclerosis, syringomyelia and tabes dorsalis observed between 1942 and 1956. On the basis of his personal findings and those of the reviewed literature the frequency of laryngoparalysis in the diseases mentioned appears unvaried with the exception of tabes dorsalis, which has shown a progressive reduction in incidence. This may be the result of more efficient social prophylaxis, particularly introduction of the recently discovered treatments.

Thornell[40] states that paralysis of the vocal cords may result from a variety of causes. The most frequent cause of bilateral paralysis of the vocal cord is injury to the recurrent laryngeal nerves during thyroidectomy. Bilateral paralysis in which the vocal cords are fixed in the median line is an extremely critical condition. Emergency tracheotomy is usually necessary because the airway is inadequate. In order to create an adequate airway Thornell devised intralaryngeal arytenoidectomy, which is performed with the aid of the Lynch suspension laryngoscope. This ingenious procedure provides satisfactory results in the majority of cases. We thoroughly concur in Thornell's warning against laceration of the mucous membrane on the medial aspect of the cartilage, as this will nullify the attempt to increase the glottic space.

The findings of unilateral recurrent laryngeal nerve paralysis in an infant 11 months old aroused considerable interest, and because of its rarity, Ross and Chambers[41] report the case. Two weeks before admission to the hospital the child cried with a hoarse voice. Laryngoscopic examination revealed abduction paralysis of the right vocal cord. No cause for the paralysis could be found at the time. Two months later the condition became worse and bilateral papilledema developed. At necropsy a tumor of the right side of the pons and medulla was found.

Asherson[42] informs us that achalasia of the cricopharyngeus invariably accompanies bilateral recurrent laryngeal nerve paralysis. In six of eight cases reported, some obstruction to swallowing of fluids could be demonstrated clinically. In this form of achalasia there is little or no obstruction in swallowing solids. Asherson reports a case of achalasia of the cricopharyngeus developing after bilateral abductor paralysis caused by bronchogenic carcinoma.

Occurrence of postoperative laryngeal paralysis does not necessarily imply that the recurrent laryngeal nerve has been severed. Ross and Sukis[43] carefully explain that there are many other causes for laryngeal paralysis and dysfunction, which are discussed in this excellent article. The anatomy and variations of the recurrent nerve and its branches are well described. The superior laryngeal nerve and its two branches are prone to injury in certain surgical procedures. The importance of preoperative examination of candidates for thyroidectomy is stressed and repeated postoperative examinations are necessary because of the amazing changes that occasionally occur in the larynx. When paralysis is unilateral, the patient can be encouraged by assurance that one-half of these paralyses are transient.

STENOSIS.

Tschiassny[44] discusses the various experiments producing laryngeal stenosis by bilateral division of the recurrent nerve with relief by inactivation of the cricothyroid muscle. The experiments were conducted on animals and later on man

with identical results. These results brought forth a vigorous discussion relative to the validity of Semon's law, and much consideration is given to this problem. Factors responsible for the cadaveric position of the vocal cords are considered, and results obtained by neurotomy of the superior and inferior laryngeal nerves are reported. Superior laryngeal neurectomy resulted in the vocal cord's assuming the cadaveric position with a good airway. In an extensive and interesting discussion Tschiassny presents factors responsible for failure and success of crico-arytenoid elimination and dwells at length on the mechanism responsible for opening the glottis as well as factors interfering with this opening. He concludes that cricothyroid elimination cannot replace modern and the more complex methods of arytenoidectomy, lateropexy, or both, but that this technique may be used advantageously when restricted to its own territory.

Milne[45] reports that introduction of an intubation tube into a patient's larynx for induction of anesthesia produced sufficient irritation in the subglottic region at the level of the cricoid cartilage eventually to cause dyspnea. It is supposed that in this patient there occurred gradual development of stenosis at the level of the cricoid cartilage as a result of chronic but not pronounced inflammation, and passage of the tube produced acute exacerbation of the condition with narrowing of the lumen. There is nothing in this report, however, to substantiate this supposition. The stenosis was corrected by laryngofissure and Thiersch graft.

SURGERY.

In a unique article Bofenkampf[46] describes a relatively simple corrective operation for relief of aphagia after poliomyelitis. The anatomy and physiology of the cricopharyngeus muscle are described. Two cases of aphagia of three years' duration after poliomyelitis treated by denervation of the cricopharyngeus muscle are reported. Through an incision on the side of the neck the thyroid and cricoid cartilages are exposed and rotated laterally and outward. The cricopharyngeus muscle is identified, and a small section is removed from its posterior aspect. In both patients thus treated normal

swallowing occurred within 24 to 36 hours, and normal swallowing has persisted.

In a most interesting and informative article on laryngeal and tracheal emergencies in the newborn, Miller[47] indicates the procedure for proper diagnosis. Obstruction of the airway in the newborn or extremely young infant is a real emergency requiring accurate diagnosis to institute life-saving measures. This at times can be difficult in these tiny patients.

Miller enumerates the various problems that may contribute to obstruction of the airway, and concludes that many conditions other than atelectasis of the newborn and laryngeal obstruction must be considered in the very small infant presenting respiratory distress that requires emergency treatment. All laryngologists should review accurate and concise articles such as this one in order to refresh partially forgotten facts.

Lewis, Snitman and Loewy[48] describe and illustrate each stage of the reconstruction methods employed by them after laryngopharyngectomy. Reconstruction of the hypopharyngeal-esophageal tube is undertaken as soon as the original wound has completely healed. The various problems arising when doing this type of work are thoroughly discussed. The illustrations of the methods of reconstruction make a difficult problem seem easy.

In addition to cordal carcinoma DeBord[49] reports use of the laryngofissure approach for removal of foreign bodies, cysts and benign tumors, and for arytenoidectomy in patients with bilateral abductor paralysis. For such conditions this approach provides better vision and enables manipulation and careful approximation of the mucosa postoperatively.

Howie[50] reminds us that the operation of laryngofissure has many uses. It is the only way to remove impacted foreign bodies in the larynx that have resisted removal by direct laryngoscopy. Injuries and trauma to the larynx may require laryngofissure to readjust displaced fragments of cartilage or stenosis occurring from various causes enumerated in this article. The main object of the laryngofissure operation is

management of early cordal cancer, and the ideal type of lesion is a tumor of low gradation in which both extremities of a mobile cord are free. Howie quotes statistics of British and American laryngologists on percentage of cures by laryngofissure and mentions use of radiation and teleradium in a provocative vein. The conclusion reached is that laryngofissure used in proper cases gives excellent results. This paper was freely discussed by Sir Victor Negus, Capps, Macbeth and many others who generally agreed with Howie and added nothing new to the original article.

Clinical studies dealing with the psychologic reaction of the patient to laryngectomy, and those studies that evaluate the progress made by laryngectomized patients in programs for speech rehabilitation, should include all patients referred to a given program. In this excellent article on evaluation of rehabilitation programs Lueders[51] advocates that a team comprised of the laryngologist, the speech therapist and the psychologist would appear to be best fitted for the task of evaluating the factors inherent in the non-cooperating group of patients. Broadly, he states that the purpose of this team would be to determine by physical and psychologic examinations and by clinical experience whether esophageal voice training or a speech prosthesis (electro-larynx) is indicated to achieve maximum rehabilitation.

In a discussion of the pseudoglottis in laryngectomized patients Micheli-Pellegrini[52] rejects the possible existence of pharyngeal elements capable of vibrating like vocal cords. He does not believe that any esophageal element, and in particular the cricopharyngeus, is able to simulate a vibrating glottis. Views of the various contributers on the subject of the so-called pseudoglottis in laryngectomized patients are discussed, mostly to disagree. Michelli-Pellegrini believes that air flowing through a narrow section would produce sound, and that the most probable site for such a narrowing space would be between the base of the tongue and the posterior pharyngeal wall. He states that the esophageal mouth constituted by the cricopharyngeus seems to represent those structures at which level fundamental sound is produced in the laryngectomized patient. From reading this article it is evident that no un-

animity of thought exists concerning the production of sound in a laryngectomized patient.

Simon[53] is of the opinion that any operation on the thyroid gland, no matter how trivial, endangers the recurrent laryngeal nerve. He believes that the incidence of nerve injury in thyroid surgery is much higher than present statistics indicate. Non-functioning recurrent nerves are a terrific handicap and frequently blight the patient's life. Simon maps out a triangle for protection of the recurrent nerve. The triangle is bounded laterally by the common carotid artery, superiorly by the inferior thyroid artery and medially by the body of the recurrent nerve on the lateral border of the trachea. Location and visualization of the nerve in this triangle practically assure that it will not be injured provided adequate care and gentle technique are observed.

Mettler[54] reports a case of a mediastinal abscess that apparently lay dormant for seven months after laryngectomy. It was diagnosed by roentgenography with use of barium, opened and drained.

VOICE THERAPY.

It has been noted that patients with simple conduction deafness tend to speak softly. Cantor[55] suggests that in advising a patient to rest his voice a conduction deafness can be produced artificially by means of ear stoppers or ear muffs.

The first part of Briess' article[56] deals with the history of voice therapy dating from the discovery of the laryngoscope by Garcia in 1854. This is followed by a discussion of the theory of voice production and the interplay of the laryngeal muscles in accomplishing this.

Next is brought out the classification of the voice therapist and the order of testing, depending upon the condition of the patient, whether there is a lesion on the cords, and the pathologic type of lesion. The methods are then considered, and the techniques of carrying out these tests are explained. This is the first part of a subsequent series of articles in which the

means of correcting muscle pairs that are functioning out of balance will be described.

Gartland[57] reports a case of injury to the thyroid cartilage without fracture producing a hematoma of the false cord and swelling of the arytenoid with fixation of the cord. They used interrupted galvanic current under direct laryngoscopy to determine whether paralysis of the cord was due to nerve injury or to dislocation of the arytenoid. The voice recovered for every day needs, but the cord remained immobile.

Livesey[58] reports the case of a 20-year-old soldier who fell and struck his neck on a tent-peg. Aphonia, coughing, hemoptysis and some pain developed immediately followed by dyspnea later. The next day emergency tracheotomy was necessary. Subsequent examination of the larynx showed a large hematoma on the left side. Livesey warns that any heavy blow on the larynx may result in severe dyspnea and such accidents should never be considered too lightly.

FOREIGN BODY.

Zoller and Bowie[59] state that several cases have been reported in the literature in which calcifications of the neck were confused with foreign bodies of the food passages. Calcification of the neck occurred in three successive cases of suspected foreign body of the esophagus in which the patient gave a history of swallowing a chicken bone and on esophagoscopy no foreign body was found. These patients presented the problem of calcification of normal laryngeal cartilages. These cases prompted Zoller and Bowie to review the literature and launch an investigation of this problem. Numerous radiographs appear in the article showing normal calcifications of isolated portions of the laryngeal cartilages giving the impression of a foreign body. It is acknowledged, however, that 98 per cent of foreign bodies of the esophagus are below the lower border of the cricoid cartilage.

Feldman and associates[60] report a case of a piece of wooden tongue depressor breaking and being aspirated by the patient during a convulsive seizure. A plea is made for care in the

use of wooden tongue depressors under similar circumstances, and the danger is emphasized.

BENIGN TUMORS.

Epstein and Winston[61] express the opinion that intubation granuloma is a rare complication of endotracheal anesthesia. There is no doubt that this condition is far more common than the 55 published cases would suggest. Epstein and Winston state that intubation granulomas are invariably found on the vocal processes of the arytenoids. We agree that the vocal process is by far the most frequent site of occurrence, but in our series of 25 unreported cases, we have had two patients in whom the granuloma occurred in the middle third of the vocal cords. The histologic picture of these granulomas is simply that of nonspecific granulation tissue. Various theories have been postulated in an attempt to explain their cause and site. Evidence is offered to incriminate the role of static pressure rather than direct trauma as the most important etiologic factor.

In an editorial[62] further emphasis is placed on the fact that greater care should be exercised in the introduction of the endotracheal tube at the time of induction of anesthesia in order to avoid the occurrence of granulomas.

Figi and Berman[63] state that although primary amyloid deposits occur in many parts of the body, they are found most frequently in the laryngotracheal region. Nine cases of amyloid tumors occurring in the larynx and trachea were seen during a period of six years, one of which is reported in detail. Hoarseness was the chief complaint of all patients, and the treatment found most effective was surgical removal.

Szpunar[64] correctly states that papillomatosis of the larynx in children represents a different morbid process from papilloma of the larynx of adults. Whereas hyperkeratotic papilloma in the adult is considered a precancerous lesion, malignant degeneration of papillomatosis occurs rarely in children. It is now thought that laryngeal papillomatosis in children does not undergo malignant degeneration unless irradiated. For this reason, there is belief that irradiation and radical

surgical excision should be banned in the treatment of laryngeal papilloma in children. Szpunar comments on the varied unsuccessful treatments used for papilloma of the larynx and then describes the treatment he used in 80 cases of multiple papillomatosis from 1946 to 1956 with good results. This consisted of injection of 0.1 to 0.5 ml. of stilbesterol into the larynx. Only one side of the larynx was injected at one time, as occasionally moderate swelling develops.

Studies in tissue growth of laryngeal papilloma were conducted by West and co-workers[65] using the suspended cell methods patterned after techniques suggested by Hanks. Observations suggested growths occurred more rapidly from laryngeal papilloma obtained from the larynx of both children and adults, than any other adult tissue cultured, either benign or malignant.

Woodman[66] presents a follow-up report of a case of a woman, aged 35 years, with multiple obstructive papillomas treated by a surgical technique in which a laryngofissure approach was used with submucosal dissection of the growth followed by insertion of an acrylic mold. The patient has remained free of recurrence for three years.

Capps[67] made a survey of the treatment of papilloma of the larynx by circulating a questionnaire to a number of colleagues in charge of clinics; he received 80 replies. He rightfully concluded that no accepted therapy will control these growths. The various treatments advocated are listed. The probable cause of stenosis in these cases is injury to the vocal cords and violation of the anterior commissure. In the treatment of such stenosis Capps advocates thyrotomy with excision of scar tissue and Thiersch grafts.

Huizinga[68] brands laryngeal papilloma as a mysterious tumor and from the present outlook fears that it will remain mysterious. Microscopically, there is no difference between papilloma in the child and in the adult, or between single papilloma and multiple papillomas. Huizinga admits that little is known about the etiology of multiple papillomas. He calls attention to the increase in incidence of multiple papillomas in Finland and the Netherlands after World War II,

which he attributes to bad hygienic and social conditions. We have been of the opinion for years that multiple papillomas occur predominantly in underprivileged children.

Ono and associates[69] present a masterly discussion of the etiology of multiple papillomas and describe experiments unsuccessfully conducted for determination of the etiology. Papilloma is the most common benign tumor of the larynx with the exception of the polyp, which is an inflammatory hyperplastic lesion. The striking features of this tumor are its frequent occurrence in children, its resistance to treatment, its tendency to transplant itself, its tendency to recur and its spontaneous regression and disappearance after its existence for a number of years. Among the possible etiologic factors discussed are hormones, chronic irritation and virus infections. The thought is expressed that clinical and experimental observations point to the fact that virus is most likely a major causative agent. This is an excellent presentation, which should be read in its entirety by those interested in this subject.

Vettorato[70] reports a survey of 38 cases of papilloma of the larynx in children and adults and describes his therapy.

Bjork and Hakosalo[71] conducted a study on the mitotic activity in benign and malignant papillomas of the larynx in adults, because it offered additional possibilities for evaluation of intra-epithelial anaplasia. Pathologic mitosis is extremely rare in benign papillomas but fairly common in malignant papillomas. The frequency of mitosis, and of pathologic mitosis in particular, is an important criterion in consideration of the possibility that papillomatous formations in the larynx are malignant.

In an interesting, informative article Bjork and Teir[72] report results of the comparative clinical and histologic study of benign and malignant papillomas of the larynx in adults. Many authorities agree that the diagnosis of malignant tumor is often difficult to make in the case of papillomas. Ullman is quoted as stating that single papillomas in adults show a tendency to malignant degeneration, and Altman is quoted as saying that intra-epithelial anaplastic changes are con-

clusive evidence of malignant growth in non-papillomatous laryngeal tumors, whereas the same signs in papillary tumors are less significant; however, Bjork and Teir consider intra-epithelial anaplastic changes to be of utmost significance in determining malignant degeneration. Critical distinction is necessary in evaluating epithelial changes since benign papillomas can show some degree of atypia.

Cracovaner and Chodosh[73] report two most interesting cases. One presented unusual symptoms and the other unusual therapeutic requirements. The first patient suddenly noted a "fleshy mass" in his mouth. On mirror examination of the larynx a large pedunculated mass was noted in the left pyriform fossa; the pedicle arose from the inferior portion of the left posterior pillar. The possibility of glottic obstruction was appreciated, and surgical removal was accomplished without difficulty. The second patient had a ventricular polyp which had to be removed by a laryngofissure approach. Other polyps were encountered on the cords. Seldom is it necessary to resort to such a procedure to remove polyps from the larynx, but large ventricular polyps present problems which at times, such as in this case, require a laryngofissure approach.

Plasmocytoma is an uncommon tumor of the soft tissues of the upper respiratory tract, and as an intrinsic tumor of the larynx it is extremely rare. Clark[74] reports such a case that caused recurrent hoarseness, dyspnea and dysphagia for two or three years. On indirect laryngoscopy a large, soft polyp was seen between the vocal cords and appeared to originate from the right ventricle. After removal, the pathologic diagnosis was plasmocytoma.

Epiglottic cysts complicating anesthesia are rather uncommon. Norris[75] reports two such cases which presented problems to the anesthesiologist. Cysts of the epiglottis are not considered rare by the laryngologist, and frequently when found, they are symptomless. Only when they assume large proportions, do they present problems. Norris discusses the origin and classification of cysts of the epiglottis and the method of handling such cases when administering an an-

esthetic. The difficulties and dangers resulting from unsuspected epiglottic cysts encountered during general anesthetization are well discussed.

Asherson[76] states that a cyst of the epiglottis is usually considered to be a benign lesion, but this classification belies its deadly nature and is misleading if the cyst is large. The most lethal of such cysts, despite their relatively small size and rarity, is the congenital juxta-laryngeal cyst that is a common cause of laryngeal obstruction in the neonate, 15 out of 20 resulting in death from asphyxia within a few weeks of life. Even in the adult, large cysts of the epiglottis become dangerous as they increase in size and a pedunculated cyst may become impacted in the glottis with resultant asphyxia and death. Asherson describes the various types of cysts and attempts an interesting classification of them. He advises peroral removal of all cysts occurring in the epiglottis and upper portion of the larynx with the aid of the Davis tonsil mouth gag and removal of the plunging intra-laryngeal cyst by the external approach. It is strange to the reviewers that Asherson does not mention utilization of suspension laryngoscopy for removal of laryngeal cysts, which to us is the ideal method.

Epstein and co-authors[77] agree that in spite of much writing on vocal cord polyps, considerable confusion still exists in the literature as to nomenclature and histologic interpretation. Their objective in this presentation was to analyze and assess the clinicopathologic significance of vocal cord polyps. They analyzed 283 cases of vocal cord polyps histologically and clinically and discuss the pitfalls of nomenclature. Polyps and their clinical variants are not neoplasms; consequently, use of such terms as fibroma, angioma or myxoma is not correct. True benign neoplasms of the vocal cord, with the exception of papillomas, are excessively rare. This is a most excellent article and should be studied by the laryngopathologist.

In an excellent, thorough article on benign tumors of the larynx, Capps[78] excluded from discussion nodes, polyps, cysts and some fibromas, which are probably the result of trauma

or inflammation. He states that compared with malignant growths of the larynx, benign tumors are rare. Papillomas are outstanding and account for nearly all growths occurring in infancy. The therapy of multiple papillomas is discussed generally with the expected conclusion that there is no specific remedy available. This latter fact is brought out forcibly by quoting numerous articles on multiple papillomas. Capps reports one case of a fibroma simulating carcinoma. Two cases of angiomas and one lymphoma are included. Five chondromas were seen, and the literature of recorded cases is reviewed.

In a discussion of benign tumors of the larynx Salkeld[79] reports a case of a non-specific granuloma of the larynx in a 68-year-old man, which was removed by laryngofissure with recurrence in four months. Radiation partially controlled the growth. The lesion was studied by several pathologists, who concurred that it was an inflammatory granulomatous tumor with abundant plasma cells. At the time of their report the patient was receiving extensive corticosteroid therapy.

Following the shock of an air raid 13 years before, a patient became hoarse, and six months later when examined, paralysis of the right vocal cord was found. In 1953 Salmon[80] investigated the larynx because of recurring hoarseness and found a large, rounded mass expanding the right aryepiglottic fold. Roentgenograms were characteristic of an ossifying chondroma of the right arytenoid. Utilizing a curved lateral incision and making use of the Woodman arytenoidectomy approach he removed the tumor, and the diagnosis was confirmed.

Stewart[81] discusses the histopathology found in a series of 104 cases of benign tumors of the larynx. Polypoid-like growths occur in the larynx with relative frequency, and these inflammatory polyps are regarded as formations of mesenchymal origin as the forerunners of fibromas and angiomas. Stewart considers the fibroma as the most common of the differentiated benign tumors occurring in the larynx. These, together with angiomas, are described thoroughly

from a histopathologic aspect and microphotographs are presented to substantiate the diagnosis.

MALIGNANT TUMORS.

Pirkey[82] reports a case of a metastatic laryngeal lesion of a proved case of multiple myelomatosis. This is extremely rare, particularly because metastasis to the larynx scarcely ever occurs. Of interest in this case was the rapid favorable response of the lesions to administration of urethane. Although the patient died, as long as urethane could be given improvement was steady; however, use of the drug had to be discontinued because it caused severe leukopenia.

In a lengthy article Lane[83] reports ten cases of polypoid or fungating oral, faucial and laryngeal lesions. The features they had in common were the presence of an intramucosal or invasive squamous cell carcinoma associated with an anaplastic stroma of sarcomatous appearance. Only two of the ten patients had a history of radiation to the region in question. Pathologic study of these cases suggested that only the carcinomatous portion had truly malignant neoplastic properties. Lane suggests that the sarcomatous component of these growths is probably not a malignant neoplastic tissue, and for this reason proposes the tentative designation of "pseudosarcoma."

Kuhn and associates[84] present a detailed, extensive statistical report on 602 cases of carcinoma of the larynx. They classified their cases not only as to age, sex and duration of symptoms but also as to site and grade. They concluded that the findings of their study "indicate that among various items of information available at the time of treatment, the site of the tumor, the histologic grade of the tumor and the microscopic infiltrative nature of the tumor, each significantly affects the likelihood of occurrence of cervical metastases from patients with squamous cell carcinoma of the larynx." They considered their findings determinants of the indications for radical procedures designed to remove cervical areas of metastatic spread in this disease. This is an excellent reference article.

Quinn and McCabe[85] found only eight cases of laryngeal metastases from distant organs in a review of the literature from 1916 to 1951. To this group they added two cases of carcinoma of the prostate gland that were metastatic to the larynx. These cases are well described, and the route by which neoplastic emboli reached the larynx is discussed.

In a most interesting and valuable contribution on pharyngolaryngectomy with primary "sleeve graft" reconstruction, Shaw and Omerod[86] describe their technique for successful handling of these difficult cases. Much stress is placed on the importance of using the proper type of self-retaining Latex stents originally devised by Sir Victor Negus. It is agreed that total pharyngolaryngectomy with primary closure by skin tube must be used when resection of the primary tumor in the hypopharynx or cervical esophagus necessitates excision of more than 70 per cent of the mucosal circumference. The incision and resection are matters of skill and surgical judgment. A rectangular split skin graft of sufficient size (4x6 inches) to create a "sleeve" type tube for the upper gullet is used. This graft is applied to the operative defect, raw surface outward, and is sutured to the lower edge of the posterior pharyngeal wall and the upper edge of the posterior esophageal wall. The Latex stent is placed in position, and the graft is carefully sutured around the hourglass stent. Complications and postoperative treatment are discussed. Those interested in this type of surgical reconstruction should read the entire article, which is much too long to cover adequately in such a review as this.

Marchetta and co-authors[87] present the end-results of a study of 158 documented cases of carcinoma of the larynx seen from 1935 to 1953. They concluded that the smoking history in this series was of little significance. They divided their cases into three categories: the first category included 56 cases in which the lesion was confined to the vocal cords without evidence of fixation. Half of these were treated by excision and half by radiation. Twenty-four months after treatment 75 per cent of the surgical group were free of disease, whereas only 50 per cent of those treated with radiation were without recurrence. The second group consisted of 60 patients with

lesions limited to the cords with fixation indicating deeper infiltration of the structures of the larynx. Eighty-three per cent of the patients treated surgically showed no evidence of recurrence at the end of 24 months, whereas only 22 per cent of those treated by irradiation were free of disease at the end of this time. In the third category were 42 patients with lesions that involved the ventricular band in addition to the true cords. All seven treated surgically were alive at the end of 24 months, but only 11 per cent of the remaining 33 who received irradiation were alive at the end of this time. Surgical treatment consisted of laryngofissure, laryngectomy or laryngectomy with radical neck dissection. Salvage efforts were instituted whenever possible. This presentation is of great interest, and only the outstanding statistics have been presented because of the length of the paper.

Jackson and associates[88] report the results of a survey of 25 years' experience with treatment of 1,066 patients with carcinoma of the larynx by operation and irradiation. Treatment consisted of partial laryngectomy in 384 patients, total laryngectomy in 374 patients, laryngectomy with radical neck dissection in 48 patients and irradiation in 260 patients. The five-year survival rate, as would be expected, was highest in those having partial laryngectomy (87 per cent) and lowest in those treated by irradiation (42 per cent). Metastasis and recurrence are discussed, and their management is outlined.

In a study of 170 case histories of patients suffering from cancer of the larynx Fior[89] was able to show that 32 relatives had suffered from some form of malignant lesion. These findings are discussed, and the importance of extrinsic factors which, by acting on the larynx, might enhance the hereditary cancer potential already existing in these subjects, is pointed out.

Foxwell[90] reports two interesting cases of carcinoma of the larynx in which he questions whether redevelopment of carcinoma 15 and 17 years later was a recurrent or a secondary primary lesion. The first patient was a laryngofissure in 1935 when the right vocal cord, which was fixed and had "an irregular white mass," was removed. Fifteen years later a

growth developed on the left vocal cord and required laryngectomy. In the second case laryngectomy was performed in 1938, and a mass developed above the tracheal stoma in 1955. We concur that the first case was a second primary carcinoma, but we cannot understand the rationale of laryngofissure in the face of fixation of the cord. The choice was undoubtedly the proper one, for there was no recurrence on the side of operation. In the second case recurrence is a possibility.

There is universal agreement with Morfit and associates[91] that cancers arising in the laryngopharynx, extrinsic larynx, and upper cervical esophagus present difficult therapeutic problems. The main method of treatment in the past has been irradiation. Cancer therapists are now turning with greater frequency to surgical excision to improve results. Eleven patients were subjected to laryngopharyngectomy, partial esophagectomy and neck dissection. The lesions were so extensive that after removal, primary closure was impossible and continuity was established with polyethylene. The method of doing this is well described. Morfit and associates conclude that when the growth can be extirpated by combined neck dissection, laryngectomy, partial pharyngectomy and primary closure obtained, the end-results indicate this is worthwhile. If the growth is so extensive that auxiliary measures must be employed, little or no increase in the salvage rate can be expected.

Snitman and Loewy[92] state that adequate surgical treatment of carcinoma of the larynx implies resection of the primary tumor and its path of direct and lymphatic spread with a true margin of safety. Laryngofissure techniques are satisfactory for restricted lesions; however, it is important to evaluate the indications carefully and adhere to them. For more extensive lesions of the vocal cord with relatively poor lymphatic-spread potentials, total laryngectomy is proper treatment. The various types of lesions occurring in the larynx and adjacent tissue are discussed. In all of these cases Snitman and Lowey comment on the type of operation considered adequate for the particular lesion. Laryngectomy in continuity with neck dissection is in frequent demand for certain

types of lesions. When indicated, they believe that laryngectomy should be of the widefield type, including the bloc from the hyoid to the trachea. This is a most interesting and informative article replete with sound judgment and good advice.

Thompson[93] reports that carcinoma of the larynx represents 4 per cent of all malignant lesions and more than 16 per cent of all laryngeal tumors. It is most prominent in the fifth to seventh decades of life but has been reported in children as young as 11 years. The ratio of men to women is ten to one and of Negro to whites per population is 1 to 1.5 per cent. Thompson presents a series of cases illustrating the types of laryngeal carcinoma and methods of treatment.

In an excellent article on laryngeal cancer Snitman and Loewy[94] deplore the inadequate type of operation in which lymphatic spread has not been covered. They believe that the treatment of advanced carcinoma of the larynx is fundamentally surgical. Relatively few patients with advanced carcinoma of the larynx demonstrate absolute contraindications to surgical management when they first seek medical aid. In the past patients with advanced tumors were referred for radiation therapy, not in the hope of cure but for presumed palliation. Many patients can now expect useful extension of their life span if given the benefit of adequate surgical excision. This article is well worth reading.

In an excellent article Holinger and associates[95] discuss the symptoms of laryngeal cancer with particular emphasis on persistent hoarseness. As the condition develops, other symptoms appear. Most of these tumors are squamous cell carcinomas. Their location is described, and the symptoms resulting are given. The diagnosis is made by indirect and direct laryngoscopy and biopsy. Treatment consists of laryngofissure, and laryngectomy alone or with radical neck dissection. The preoperative care and especially the postoperative nursing care are described in detail. This is an excellent article for floor nurses as well as private duty nurses caring for this type of patient.

Ormerod[96] defines pharyngolaryngectomy as total excision

of the larynx with at least half of the pharyngeal tube. He adequately describes the pathology and surgical procedure, but dwells more on the methods of repair after this formidable operation. His method of suturing and repairing the pharyngeal defect is well presented. He points out that the condition of these patients is much improved by this drastic surgical procedure, the discomfort occasioned by the presence of a large septic malignant lesion in the pyriform fossa where air and food passages cross, being exchanged for the well being and comfort of a healed and clean alimentary tract.

The immediate effects of too much Roentgen-ray irradiation on the skin, subcutaneous tissue and cartilage are well known. Reports of late damage to the deep tissues of the pharynx, larynx and upper esophagus are not common. Henry[97] reports two cases of damage from prolonged irradiation for noncancerous lesions ten to 15 years before. Severe dyspnea and dysphagia developed in one patient, and in the other carcinoma of the larynx developed. Henry voices the opinion that when cancer occurs several years after prolonged roentgenotherapy for a noncancerous lesion at the site of irradiation, it may be termed an irradiation cancer.

The prognosis of carcinoma of the epiglottis is much worse than that of the vocal cords. There seems to be a wide variation in the surgical management of this condition. McCall and associates[98] believe that the solution lies in use of more radical excision. They advocate total laryngectomy, including the epiglottis and radical neck dissection (unilateral if the growth is localized to one side, but bilateral in two stages if the growth is in the midline). To substantiate this procedure the lymphatic supply of the epiglottis and larynx is illustrated. Statistics during a period of ten years show a higher incidence of recurrence in patients having less radical operations. Helpful advice in performing bilateral radical neck dissections is offered.

In an interesting and unusual paper Damsté[99] describes improvement of the voice of a patient after total laryngectomy by changing the site of the pseudoglottis. For two years the laryngectomized patient spoke with a weak pharyngeal voice.

Fluoroscopy confirmed the fact that air did not enter the esophagus because of inability to relax the sphincter of the esophagus. Educational methods soon brought results. A large esophageal bougie was used daily to dilate and relax the cricopharyngeal sphincter. The patient gradually succeeded in swallowing air and pressing it out of the esophagus, and within two months a satisfactory conversational voice had developed.

In an interesting article Haas[100] presents his recent work, although limited, on the betatron treatment of carcinoma of the larynx. This presentation offers food for thought and again brings up the old argument of radiation vs. excision as curative therapy for carcinoma of the larynx. The advantages of the betratron are: greater penetration, lesser surface dose, insignificant side scattering and, therefore, less osseous absorption and risk of necrosis of bone and bone marrow depression. This type of treatment employs less radiation and causes less discomfort to the patient both during and after radiation. Only ten cases of carcinoma of the larynx are reported; three of the ten patients are dead, and at the time of the report only one has been living for more than five years.

McReynolds[101] considers carcinoma of the larynx an interesting and challenging problem in which the ideal treatment is yet to be found. He reviews 244 cases of laryngeal cancer seen at the University of Texas Medical Branch during the past 15 years. He reviews the modes of therapy employed and discusses at length and accurately the significance, potentialities, method of treatment and prognosis of leukoplakia. Although his percentage of reported cures seems slightly low, his advice and surgical management are sound.

Struben[102] comments on the difficulty of classifying laryngeal carcinoma, as evidenced by the divergent classifications proposed by various laryngologists. He presents a classification proposed by the joint staffs of the Radiotherapeutic Institute of Rotterdam and the Netherlands Cancer Institute of Amsterdam, which is much the same as that suggested by the International Committee for stage-grouping in cancer in 1953. A universally accepted classification would make it

possible to compare statistics and results and map out modes of treatment for various carcinomas of the larynx more accurately than we now can. Struben believes that carcinoma of the larynx should be treated only in special clinics in order to enable the staff to enlarge their experience and thus provide the patient with the best treatment possible.

The rare incidence of fibrosarcoma of the larynx, says Johnston,[103] can best be appreciated by comparison with the incidence of other cancerous tumors of the larynx. Figi reported four cases of sarcoma at the Mayo Clinic from 1910 to 1933 as contrasted with 713 cases of carcinoma of the larynx. Johnston reports three cases of fibrosarcoma and 686 cases of carcinoma seen between 1947 and 1956. The ratio of sarcoma to carcinoma is 1:117. Fibrosarcomas rarely metastasize, but when they do, extension is through blood vessels or infiltration. The tumor is usually smooth and rounded, and the diagnosis is made by microscopic examination of the tissue. Complete surgical removal is necessary for cure. Sarcomas are radioresistant. Johnston describes the therapy instituted in his cases with appropriate comments.

In a series of two articles Davis[104] presents first a lengthy historical sketch of carcinoma of the larynx followed by a detailed discussion of the incidence, etiologic factors, classification, pathologic processes and diagnosis. He emphasizes the necessity of repeated biopsies on clinically malignant-appearing lesions. In the second part of this article management of carcinoma of the larynx is well presented. The indications and technique for laryngofissure and laryngectomy are considered. Davis believes that there is a place for irradiation in the treatment of carcinoma of the larynx and quotes the views of numerous radiotherapists. In this article Davis has accomplished his objective to describe the essential facts of carcinoma of the larynx in such a way that the physician who is not a specialist in laryngology, encountering a patient with symptoms indicating the disease, would know how to proceed.

In a most comprehensive article Shaw[105] discusses all phases of cancer of the extrinsic larynx and laryngopharynx. Tele-

radiation offers hope in the treatment of carcinoma of the true cords, but it fails completely to improve unsatisfactory survival rates of patients with carcinoma in other parts of the larynx or laryngopharynx. Shaw advocates the classical method of radical *en bloc* dissection of the larynx and cervical glands, together with removal of the sternocleidomastoid and omohyoid muscles, the internal jugular vein and the submaxillary gland. Early diagnosis and early adequate surgical treatment remain the most powerful weapons for attacking cancer. Radical surgical excision will never be the ultimate answer, but is the most effective single method available until biochemical control can be achieved.

In an interesting and thorough article Goolden[106] states that the carcinogenic properties of ionizing radiation have been recognized for many years. Radiation tumors that have developed in the pharynx and larynx are discussed. Most radiation-induced tumors are squamous cell carcinomas. Five cases of radiation cancer of the larynx have been reported in the literature. These patients had irradiation for tuberculous adenitis and exophthalmic goiter. In addition to these, 12 cases of postcricoid carcinoma after irradiation for thyrotoxicosis are reported. Goolden classifies postcricoid carcinoma under pharyngeal tumors, but in our opinion, they could be equally as well classified as occurring in the larynx. The latent interval between treatment and development of carcinoma ranged from ten to 35 years. Goolden points out that with the new type of therapy now being used in irradiation there is less chance of development of post-radiation tumors.

Henken[107] does not consider the primary diagnosis of carcinoma nor does he attempt the differential diagnosis. He compares the current nomenclature of laryngeal carcinoma in the United States and the Netherlands. The nomenclature is surprisingly similar basically in the large medical centers of both countries. Based on classification the surgical indications are practically the same except more postoperative roentgenotherapy is administered abroad, and in some of the centers all patients are given a trial of roentgenotherapy preoperatively. The comparative statistics are much more favorable in the United States than in the Netherlands, but the main

reason is that during the war years, Europe did not have the benefit of group comparisons and conferences. This is an excellent article.

Foxen[108] presents the results of a survey of 206 cases of carcinoma of the endolarynx treated by surgeons and radiotherapists during the past 23 years. He briefly considers the anatomy, symptomatology, site of the disease, mobility, histology, treatment and prognosis. Lack of mobility generally constitutes a firm surgical indication in operable cases. Teleradiotherapy is the method of choice in mobile glottic cases. Most patients in this series received some form of irradiation as their first and chief form of therapy. Foxen reports that midcord carcinomas respond favorably to teleradiotherapy; however, cases of reduced mobility, and supraglottic and bilateral lesions give disappointing results with this type of therapy. Foxen believes that laryngectomy unaccompanied by neck dissection is never indicated. Apparently he does not appreciate the value of laryngofissure for limited cordal lesions, for he definitely states that "a laryngofissure operation is now considered most suitable for nonmalignant and premalignant conditions."

Trible[109] discusses the effect of preoperative radiation on subsequent operation in carcinoma of the larynx. He believes that radiation has a place in the treatment of early lesions of the vocal cords but that all other lesions should be removed surgically. Roentgen-ray in conventional dosage administered by the Coutard method does not adversely affect performance of laryngectomy; however, radiotherapy delays wound healing, increasing the duration of hospitalization, and frequently necessitates plastic procedures. After higher doses of roentgen-ray radionecrosis may develop. Comparison of the postoperative duration of hospitalization in a series having laryngectomy alone and a group having previous radiotherapy showed an average stay of 28 days for the former and 40 days for the latter. The impression gained from reading this paper is that Trible is opposed to preoperative radiation.

Woods[110] prefers a full course of deep Roentgen-ray therapy for all patients with carcinoma of the hypopharynx. If radia-

tion fails, or there is a recurrence, surgical treatment is undertaken. In the presence of cervical metastasis, surgical excision is advocated. The result of this policy is that most patients who require surgical treatment have had full courses of deep Roentgen-ray therapy and devitalization of the skin. The radical type of excision necessary in these patients creates such a defect that reconstruction is difficult. Woods suggests insertion of a polyethylene sponge in a pocket created between skin flaps and prevertebral fascia. A thick split skin graft is sewn around this polyfoam sponge. The results obtained in such reconstruction of the pharynx have been most satisfactory.

Hara[111] reports results of a study of the five-year survival rate of 38 patients with carcinoma of the larynx. The symptomatology, diagnosis and pathology are considered, but only the essential features of the operative procedure are discussed. This report is well presented and Hara makes a plea to endeavor to make people more conscious of the dangers of persistent hoarseness.

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EXPERIMENTAL STUDIES IN FIXATION OF THE STAPES AND FENESTRA OVALIS.*†

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Stapes mobilization, as put forward by Rosen[1] and further developed by many followers,[2-8] has been an important contribution to the surgical treatment of otosclerosis.

In cases of failure to mobilize the footplate of the stapes, Rosen[9] proposed the fenestra ovalis operation. Essentially, the procedure consists of creating an opening in the margin or body of the footplate of the stapes as close to the posterior crus as possible. Removal of the incus facilitates exposure of the footplate and creation of the fenestra. Rosen[10] has reported that normal or near-normal hearing was obtained in many cases, both when the ossicular chain remained intact and when the incus was removed. Consequently, Rosen[11] stated: "The Helmholtz concept of the transformer action of the intact ossicular chain is a *sufficient* but not a *necessary* condition for normal and near-normal hearing."

The concept that an intact physiological ossicular chain is a *necessary* condition for normal hearing prompted this investigation. The principles of the transformer action of the middle ear mechanism and the effects which follow injury of the ossicular chain, are fully explained in the comprehensive work of Wever and Lawrence,[12] Békésy and Rosenblith,[13] Stuhlman,[14] Stevens and Davis,[15] and others.

The investigation to be reported here was undertaken for

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the purpose of studying the effect of the fenestra ovalis, as described by Rosen,[10,11] on the transformer action of the middle ear mechanism in experimental animals. This study may also help in the understanding of the results claimed by Rosen[10] but denied by others.[8,16]

Thresholds and maximum voltage of both cochlear microphonics and action potentials were used as indices of the transformer action. It is understood that the electrophysiological method of measuring sensitivity at the peripheral level is related but differs from the over-all sensitivity as determined by behavioral methods in animals or audiometric tests in human beings. The electrophysiological method of recording cochlear responses is specific for the study of the mechanism of the peripheral ear, including the transformer action. The behavioral or audiometric method is more suitable for studying the auditory system as a whole, which includes peripheral and central neural mechanisms.

The decision to use thresholds and maximum voltage of cochlear microphonics as an index of the transformer action is justified by previous experience.[12,17,18,19] Measurements of action potentials were included in this study, because they represent the final event of the peripheral mechanism.

METHOD.

The experiments were carried out on 19 cats anesthetized with pentobarbital sodium, 37.5 mg. per kilo body weight, in a single dose.

The operation was performed in three stages: first, following removal of the mastoid cells and bone of the posterior and superior walls of the external canal, the round window niche was exposed. An electrode of silver wire, enameled except for the flat tip, was allowed to rest on the membrane of the round window. The opening in the bulla was sealed with dental cement. An ear speculum coupled to a PDR-10 transducer by a plastic tube 80 mm. long, was tightly attached to the external canal.

Thresholds and maximum voltage for cochlear microphonics

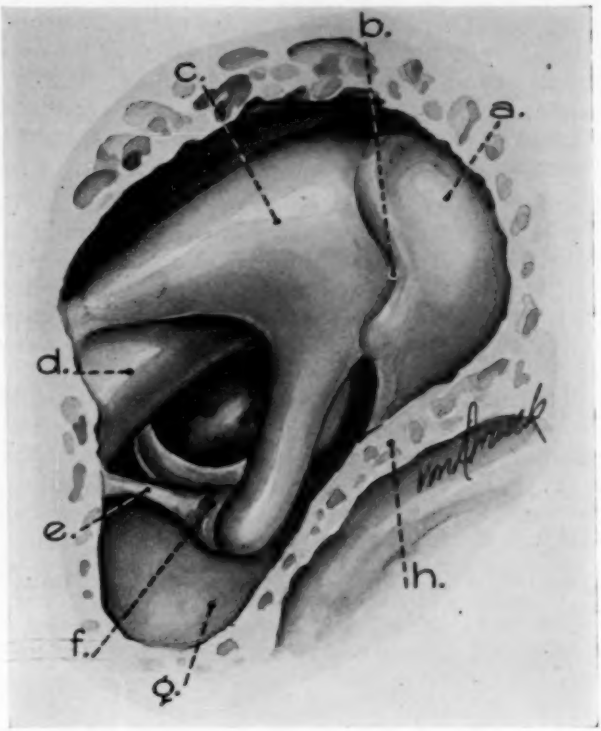

Fig. 1. Freehand drawing of ossicular chain as seen after opening the attic. a. malleus. b. malleoincudal articulation. c. incus. d. facial canal. e. tendon of stapedius muscle. f. head of the incus. g. tympanic cavity. h. ridge of superior external canal.

(CM) were measured by octaves from 125 to 8,000 c.p.s. sine waves. Thresholds are here defined after Pestalozza and Davis,[20] and maximum voltage as the voltage of CM for a predetermined set of the attenuator. The input was fixed at an intensity sufficient to give an output of CM near the point of non-linearity. Stimuli at higher intensity may produce, in the long process of measurements, undesirable fatigue effects. For observing changes in action potentials (AP) 8,000 c.p.s. tone pips were used.

The second stage of the operation consisted of exposing the attic so that incus and stapes with its footplate were widely visualized. Fig. 1 shows a freehand drawing of the ossicular chain, as seen under a Zeiss microscope (16X). The cochlear responses were measured again. Some animals were used to study modifications of cochlear responses after various types of injury of the ossicular chain.

The third stage of the operation was attachment of a device for mechanical fixation of the stapes and creation of the fenestra ovalis. The device consisted of a small pulley with a thread which had a thin steel hook on one end and a scale pan for holding weights on the other end. The hook was anchored to the neck of the stapes. Cochlear responses were measured after adding to the scale pan weights from 10 to 40 gm. Fenestration of the footplate was made with a sharp needle as close to the posterior crus as possible. The effect of the fenestra ovalis was studied in four types of preparations:

1. Normal ossicular chain.

2. Injury of ossicular chain.

3. Normal ossicular chain plus mechanical fixation of stapes.

4. Injury of ossicular chain plus mechanical fixation of stapes.

RESULTS.

A. Cavity Effects.

The technique for fixation of stapes, making fenestra ovalis and other surgery of the ossicular chain required opening the attic. This eliminates the volume elasticity of the middle ear cavity. The question was raised as to whether there is a corresponding change in the cochlear responses. The answer to this question is important in the final assessment of our results.

Comparison of the results obtained before and after opening the attic showed that the opening produced modifications in thresholds of CM. Low frequency sensitivity (125 and

250 c.p.s.) improved by an average of 10 db. while the other frequencies sometimes showed variations of a few decibels. Sensitivity of AP was not modified.

Commentary. These experiments confirmed the results of Wever, Lawrence and Smith;[21] that is, opening of the middle ear cavity causes only minor changes in transmission. For this reason we decided to use the cochlear responses given by the initial opening of the attic as the reference level; thus, in the course of this paper the results are generally expressed in terms of losses or gains in decibels relative to that reference.

B. Injury to the Ossicular Chain.

The effect of injury to the ossicular chain has been fully explored in the past;[12] however, we reproduced those lesions which pertained to our aims.

1. Disarticulation of Incudostapedial Joint. Separation of incus from stapes was done by applying traction on the long process of the incus with a Shambaugh hook. When traction was released, the incus always returned to contact with the stapes if the malleoincudal joint and posterior ligament had not been damaged. Restoration of contact between the two bones was facilitated by sound stimuli. To obtain a permanent gap it was necessary to rupture the posterior ligament and capsule of malleoincudal joint.

A gap of 1 mm. or more between incus and stapes produced a large impairment of thresholds and maximum voltage of both CM and AP. A representative case is illustrated in Fig. 2. *Curve A* represents the threshold shift of CM after disarticulation. Low frequencies could not be differentiated from the background noises even at the highest intensity input. In the middle range the losses were 40 to 60 db. and for higher frequencies 30 to 40 db.

Impairment of maximum voltage of CM also increased from high to low tones, the losses being between 20-30 db. for high frequencies, and 30-40 db. for the middle range. This change in amplitude of CM for 2,000 c.p.s. sine waves can be estimated from Record 2. The loss was 27.2 db., which represents about 95 per cent of the reference (Record 1).

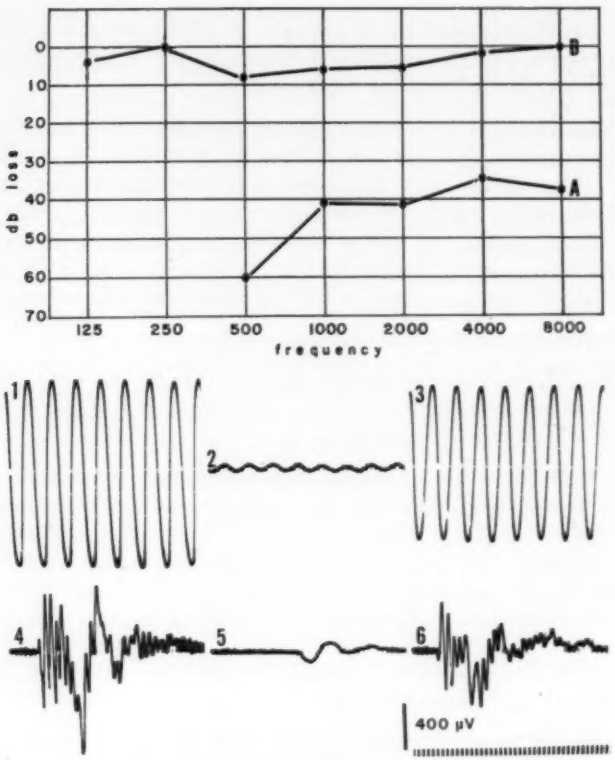

Fig. 2. Cat A-479. Effect of disarticulation of incudostapedial joint followed by reconstruction. Changes in thresholds of CM are represented by Curves A, disarticulation of incudostapedial joint; and B, reconstruction. Changes in amplitude of CM for 2000 c.p.s. sine waves at 59 db. above threshold are shown by Record 1, reference; Record 2, disarticulation; and Record 3, reconstruction. The corresponding changes in amplitude of AP for 8000 c.p.s. tone pips at 67 db. above threshold are represented by Records 4, 5 and 6. In this and following figures, time calibration is 10,000 c.p.s.

Changes in AP were considerable. Threshold shifted as much as 55 db. and amplitude was reduced to 30 per cent or less of the reference level, as Record 5 illustrates.

A careful reconstruction of the ossicular chain by returning the incus to its normal position may produce nearly complete recovery of cochlear responses. These findings are also

shown in Fig. 2. *Curve B* represents the losses in sensitivity of CM after reconstruction, and Records 3 and 6 the recovery in voltage of CM and AP respectively. The degree of recovery of these parameters only varied slightly from one animal to another.

Commentary. The results of these experiments showed that disarticulation of the incudostapedial joint was accompanied by a considerable loss in both sensitivity and amplitude of cochlear potentials. This finding is particularly interesting, because as Wever and Lawrence[12] stated, "The loss just described is considerably greater than we should expect simply from the elimination of the transformer action of the middle ear mechanism, which we have found to average 28 db." The authors[12] gave two reasons for this effect: one is that incus, malleus and tympanic membrane "are in the path of the incoming sound and cause both reflection and absorption of this sound to no good purpose." Wever, Lawrence, and Smith[21] measured the sensitivity of CM before and after disarticulation of the incudostapedial joint, and again after removal of incus, malleus and tympanic membrane. After removal of the latter three structures, there was a recovery of about 15 db. in the middle range of the threshold shift, produced by the incudostapedial disarticulation. These experiments were repeated in two animals of the present series with the same qualitative result. The other factor, which Wever and Lawrence[12] cited, is that "the sounds have more nearly equal access to both oval and round windows. Their stimulating effects upon the inner ear tend to be counteractive." The contribution of this factor, as determined by Wever,[22] is about 12 db. A third additional factor impairing responses is the loss of the lever ratio which, in the mechanical advantage of the ossicular chain of the cat, amounts to a factor of 2.5.[12]

2. Removal of Incus. This injury produced similar, and in some animals a larger impairment of cochlear responses than disarticulation of the incudostapedial joint. A representative case is illustrated in Fig. 3. Threshold shift of CM was 42 db. or more and that of AP was 55 db. Amplitude of CM lost 23 db., which represents a reduction of 93 per cent of the

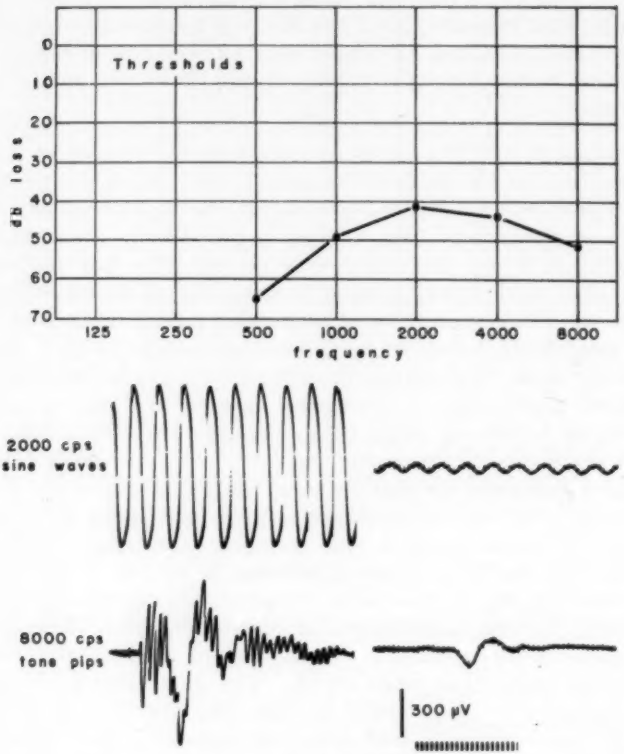

Fig. 3. Cat A-455. Effect of removal of incus. Thresholds of CM lost 42 db. or more. The records in the left column are references; 2000 c.p.s. sine waves at 74 db. above threshold of CM and 8,000 c.p.s. tone pips at 76 db. above threshold of AP. The losses after removal of incus were 93 and 84 per cent respectively. This can be estimated from the records on the right column.

reference level. Changes in amplitude of both CM and AP can be estimated from the records shown on the right column of Fig. 3.

Commentary. The impairment of responses following removal of the incus is due to the same factors that produce a threshold shift when the incudostapedial joint is simply disarticulated. From the results of Wever and Lawrence,[12] and

Wever et al.,[21] which are supported by the experiments reported here, it is assumed that a gap in the ossicular chain of a human ear must produce equal or similar results.

If the incus be removed and the malleus and tympanic membrane remain in their normal positions, they bring about one condition under which the transformer action of the middle ear mechanism cannot be fully restored. In the fenestra ovalis operation, as proposed by Rosen,[10,11] the malleus and tympanic membrane are usually left in their normal positions, where they act as an attenuator of the incoming sound, the attenuation being of the order of 15 db.[21] This loss cannot be recovered as long as the malleus and tympanic membrane remain in position and a gap exists between them and the inner ear.

The recovery of cochlear responses after reconstruction of the ossicular chain (see Fig. 2) is significant in two ways: first, it supports the rationale of stapes mobilization[1-8] and similar operations[23] for otosclerosis, and also of tympanoplastic surgery. The efficiency of these procedures depends upon success in reconstructing the transformer action of the ossicular chain as it normally exists; second, the posterior ligament of the incus and capsular ligaments of the incudostapedial and malleoincudal articulations seemed to play a minor role in transmission of sound. All these ligaments can be broken and the incus displaced; upon reconstruction, however, the cochlear responses may return to the reference level. This indicates that the functional properties of the incus during transmission of sound depend more on its contiguity with the malleus and stapes than on their attachments. The importance of these attachments, as conceived by Helmholtz,[24] Dahmann[25] and others, seems to have been overemphasized.

3. Removal of Incus and Stapes. These experiments were done because they represent a modification of the fenestra ovalis operation, as proposed by Rosen.[11] Removal of the stapes is equivalent to making a fenestra ovalis in the human being as large as the oval window.

The results showed that the impairment of cochlear re-

sponses due to ablation of incus and stapes together was of the same order of magnitude as removal of incus alone.

Commentary. These experiments indicate that a fenestra ovalis of the size of the oval window, leaving malleus and tympanic membrane undisturbed, produces a loss in cochlear responses larger than simple elimination of the transformer action. At least some of the reasons for this impairment are those just mentioned.

This or similar procedures had been used in the past for surgical treatment of otosclerosis. The approach proved to be unsatisfactory and was abandoned. The reasons for its failure are now understood.

C. Mechanical Fixation of Stapes.

The mechanical device for fixation of the stapes was arranged in such a manner that the direction of the pulling force acted approximately parallel to the main axis of the anterior crus. Avoiding contact of thread and/or hook with surrounding tissues reduced frictional forces to a minimum. Because of the anatomical arrangement and direction of acting force, we assumed that the anterior region of the footplate was retracted appreciably.

The weight of hook, thread and scale pan was 0.8 gm. Attachment of this mechanical device produced minor losses in both thresholds and maximum voltage of cochlear responses. Most of the experiments in mechanical fixation made use of a maximum weight of 30 gm. This criterion was adopted because of limitations imposed by resistance of the stapes which usually broke with a weight of 40 gm.

Addition of weights in steps of 10 gm. each produced a characteristic pattern in cochlear responses, as Fig. 4 illustrates. *Curves A, B and C* represent threshold shifts of CM after adding 10, 20 and 30 gm. respectively. The impairment increased from high to low tones. Fixation with 30 or 40 gm. produced a loss of 15 to 20 db. for high frequencies, 35 to 40 db. for the middle range, and no responses were seen for the low frequencies. Changes in maximum voltage of CM are illustrated in Records 1, 2 and 3, which correspond to the

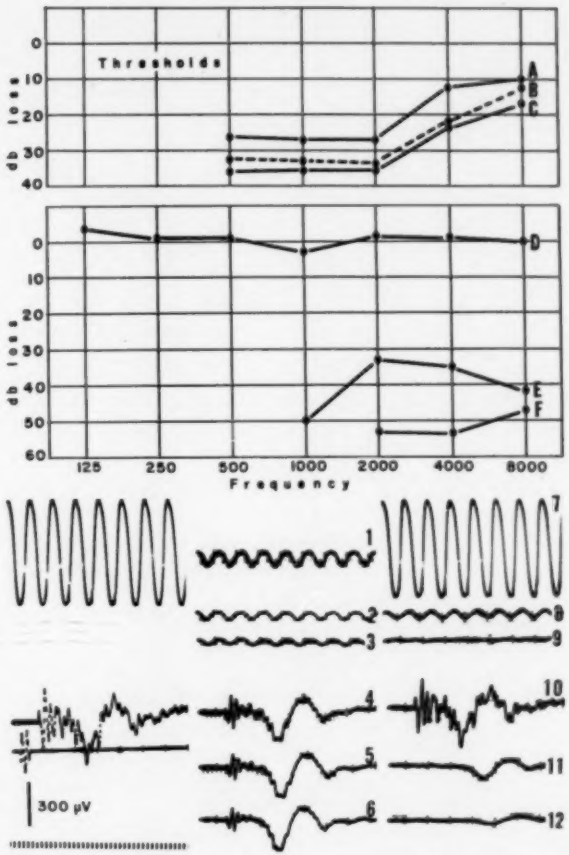

Fig. 4. Cat A-454. Effect of simple mechanical fixation of stapes. Records in left column are reference for amplitude of CM and AP for 2,000 c.p.s. sine waves at 66 db. above threshold and 8,000 c.p.s. tone pips at 67 db. above threshold respectively. Curves and other records represent the following: Fixation of stapes with 10 gm., Curve A and Records 1 and 4. Fixation with 20 gm., Curve B and Records 2 and 5. Fixation with 30 gm., Curve C and Records 3 and 6. Removal of weight, Curve D and Records 7 and 10. Removal of incus without fixation of stapes, Curve E and Records 8 and 11. Finally, fixation of stapes without incus, Curve F and Records 9 and 12.

effect of fixation upon CM for 2,000 c.p.s. with 10, 20 and 30 gm., respectively. The losses were 5 to 10 db. for high frequencies and 25 to 30 for the middle range.

The average loss in thresholds of AP after fixation with 30 gm. was 16 db. Changes in amplitude can be estimated by the Records 4, 5 and 6, which correspond to the effect of 10, 20 and 30 gm., respectively. Notice that the amplitude of AP was little affected by the increasing weight.

All the curves and records shown in Fig. 4 belong to one animal, which was considered to be representative of this series. Slight variations in both sensitivity and maximum voltage of cochlear responses were found from animal to animal.

The question whether fixation of the stapes may have some traumatic consequences was explored in many cases by removing weight and mechanical device. After this the responses fully recovered the reference level, as Fig. 4 illustrates. *Curve D* corresponds to sensitivity of CM, Record 7 to maximum voltage of CM at 2,000 c.p.s. and Record 10 that of AP at 8,000 c.p.s.

The impairment produced by fixation of the stapes with 30 gm. increased considerably after removal of the incus. The losses in sensitivity and amplitude of both CM and AP were consistently larger than 50 db. These findings are shown in Fig. 4. *Curve E* (sensitivity of CM), and Records 8 (amplitude of CM) and 11 (amplitude of AP) correspond to the effect of removal of incus only. Subsequent impairment of fixing stapes with 30 gm. is shown by *Curve F* and Records 9 and 12.

Commentary. The results on simple mechanical fixation of the stapes without other lesions of the ossicular chain, confirmed the findings of Smith.[26] The increasing impairment from high to low tones is due to "the fact that fixation of stapes adds a great amount of stiffness as well as frictional resistance to the moving system."[12]

The profound impairment in sensitivity of CM following

fixation of the stapes with incus removed represents the combined action of several factors:

a. Removal of incus eliminates the transformer action of the middle ear mechanism which accounts for 28 db.

b. Malleus and tympanic membrane absorb and reflect acoustic energy. This shifts the sensitivity curve to about 40 db. loss.

c. Mechanical fixation of stapes increases stiffness reactance and frictional resistance which add to the previous factors.

d. The lever ratio of ossicular chain is definitely lost.

e. Mechanical fixation of the stapes produces a blocking effect in the oval window and consequently the sound pressure is applied only in one window, *i.e.*, the round window. Since there is now no point of pressure discharge, the mass displacement of cochlear fluids necessary for stimulation of sensory organs either cannot take place or is largely reduced.

Combination of all these factors produces the residual hearing illustrated by *Curve F* (sensitivity of CM) and Records 9 (amplitude of CM) and 12 (amplitude of AP) of Fig. 4.

This interpretation may be considered to be a restatement of that given by Wever[22] after several experiments on blocking the round and oval windows.

D. The Fenestra Ovalis.

Exposure of the footplate of the stapes in the cat is a minor surgical problem. A wide view of it can be obtained by removing the attic bone as close to the posterior ligament of the incus as possible and drilling down the facial canal.

The fenestra ovalis was made with a steel wire which was sharpened with sand paper to a diameter of about 100 microns at the tip. The holes were irregular in shape and of a size larger than the stylet. Sometimes the fenestration produced fractures which occasionally extended to the margins of the footplate. The fenestra ovalis was preferably made near

the posterior crus, but in some animals it was located in the center. In many experiments it was enlarged once or twice in order to correlate its size with cochlear responses. The fenestra ovalis was always followed by a stream of perilymph which filled the oval window niche and sometimes ran into the attic and/or tympanic cavity. In our experiments it was not possible to keep the oval window niche free of perilymph longer than a few seconds.

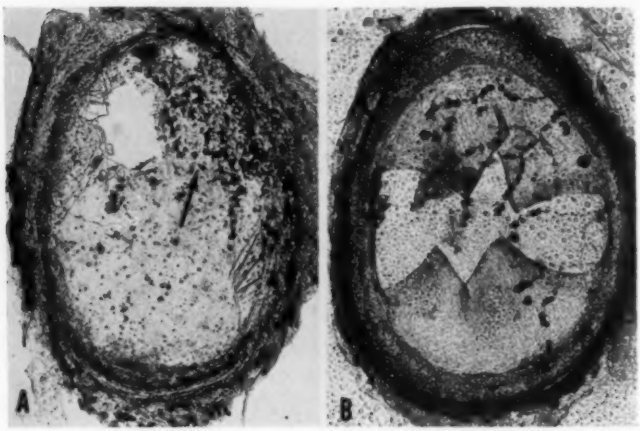

Fig. 5. Samples of fenestra ovalis made in the footplate of stapes in the cat. A. Small fenestra after perforating the footplate just once. Arrow points to a fracture which extends to the margin. Enlargement of fenestra ovalis produced generally holes of the same shape but associated with several fractures. B. This unusual fenestra ovalis was found in one case. The hole was enlarged twice. Unstained. X50.

In six animals the temporal bones were removed at the end of the experiment and fixed in Heidenhain-Susa solution. Subsequently the stapes and frame of the oval window were carefully dissected and mounted in thick Canada balsam for photographic reproductions and microscopic measurements of the fenestra ovalis. Fig. 5 shows two different footplates with two kinds of fenestrae, as seen from the vestibular side. The area of the fenestra ovalis varied from 0.075 mm.^{2} (Fig. 4-A) to 0.320 mm.^{2} (Fig. 4-B).

Commentary. These observations are interesting because they showed that the footplate is very brittle. The perforation with a stylet may produce fractures which extend to the margins, and both size and shape of the hole are unpredictable. It is possible that in human subjects the fenestra ovalis may produce fractures which act as a stapes mobilization.

The fact that the fenestra ovalis produced a stream of perilymph which filled the oval window niche is important because this fluid and the fluid of the inner ear make a continuous medium through the fenestra. The significance of this observation will be presented in a following paragraph.

E. Effects of Fenestra Ovalis.

1. Normal Preparations.

The fenestra ovalis performed in a normal ossicular chain in general produced minor changes in cochlear responses. In some animals the reference level was not modified during 1 to 2 hours of observation, while in others sensitivity of CM may lose 10 db. at some frequencies. These changes were observed in low and middle tones while high frequencies consistently remained unchanged.

Commentary. These preparations are important because they showed that a careful performance of the fenestra ovalis was not accompanied by immediate damage to the sensory organs. This is true only for acute preparations. The loss of as much as 10 db., which was observed in some frequencies of some animals, may be related to fracture of the footplate and accumulation of fluid in the oval window and tympanic cavity.

2. Injury of Ossicular Chain Without Fixation of Stapes.

The procedure consisted of creating a fenestra ovalis first and then severing the ossicular chain in several ways, or vice versa.

The results were essentially the same as in the series in which the ossicular chain was damaged without fenestration of the footplate. A case is illustrated in Fig. 6. *Curves A* and *E* represent thresholds and maximum voltage of CM after

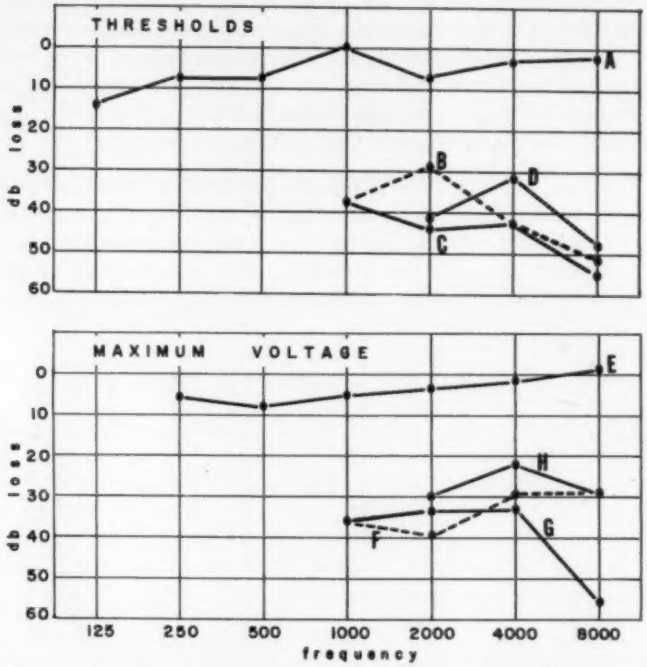

Fig. 6. Cat A-403. Effect of fenestra ovalis with injury to the ossicular chain. Stapes not fixed. Curves A and E represent thresholds and maximum voltage of CM after fenestra ovalis alone. Disarticulation of incudostapedial joint produced losses represented by Curves B and F, respectively. Removal of incus, Curves C and G and removal of remaining malleus and tympanic membrane, Curves D and H.

the fenestra ovalis alone. Disarticulation of the incudostapedial joint produced a threshold shift of CM of about 40 db. or more for most frequencies (*Curve B*). These losses increased when the incus was removed (*Curve C*). Finally, when malleus and tympanic membrane were extirpated thresholds improved (*Curve D*); however, the final loss exceeded 40 db. The corresponding changes in amplitude of CM are shown in *Curves F, G* and *H*. Sensitivity and amplitude of AP followed a similar pattern.

Commentary. This series demonstrated that a fenestra

ovalis in a mobile stapes did not restore the transformer action which had been altered by injury to the ossicular chain. Even after removal of the malleus and tympanic membrane, the losses exceeded those produced by simple elimination of the transformer action of the middle ear mechanism. The cause of impairment following injury of the ossicular chain has already been explained.

3. Ossicular Chain Intact with Fixation of Stapes.

These conditions are shown in Fig. 7. The freehand drawing from a preparation shows undamaged ossicular chain, the hook anchored on the neck of stapes and a simplified fenestra ovalis near the posterior crus.

The impairment of thresholds and maximum voltage of both CM and AP produced by mechanical fixation of the stapes remained essentially unchanged after the fenestra ovalis. Some animals showed improvement of about 5 db. for thresholds of CM; others, like the one illustrated in Fig. 8, presented losses of as much as 10 db. *Curve G* represents threshold shift of CM after fixation of the stapes, and *Curve H* the further shift following the fenestra ovalis. The corresponding changes in maximum voltage of CM for 1,000 c.p.s. are shown on Records 4 and 5, and those for 4,000 c.p.s. in Records 6 and 7. Records 8 and 9 illustrate changes in AP. Notice in Fig. 8 that cochlear responses recovered the reference level after removal of weight. This is shown by *Curve I* and Records 10, 11 and 12.

The size and location of the fenestra ovalis did not produce changes which were different from those already described.

After fixing the stapes with 30 gm. and creating the fenestra ovalis, the attic was closed with dental cement in several animals. The results showed impairment similar to that seen with attic open.

Commentary. This series clearly demonstrated that the fenestra ovalis did not restore the losses produced by fixation of the stapes, thereby indicating that the transformer action of the middle ear mechanism is a necessary condition for normal hearing as measured at the peripheral level.

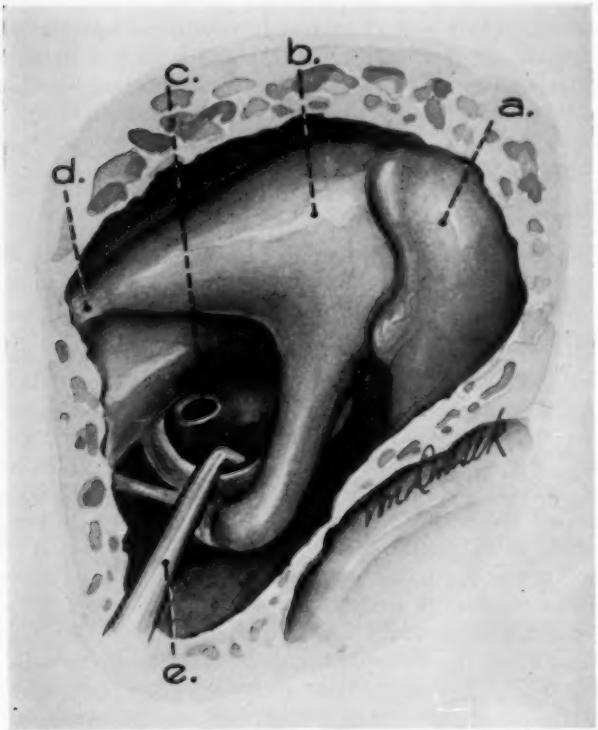

Fig. 7. Freehand drawing of the ossicular chain, showing the placement of hook for mechanical fixation of stapes, and a simplified fenestra ovalis. A. malleus; b. incus; c. fenestra ovalis; d. posterior ligament of incus; e. hook for mechanical fixation of stapes.

The question of whether fixing the stapes and creating the fenestra ovalis may produce some injury in the conductive mechanism and/or sensory organs was ruled out because cochlear responses recovered the reference level after removal of weight.

Factors such as attic open or attic closed did not modify the impairment already established. Similarly size and location of fenestra ovalis seemed not to be critical factors in this type of preparation.

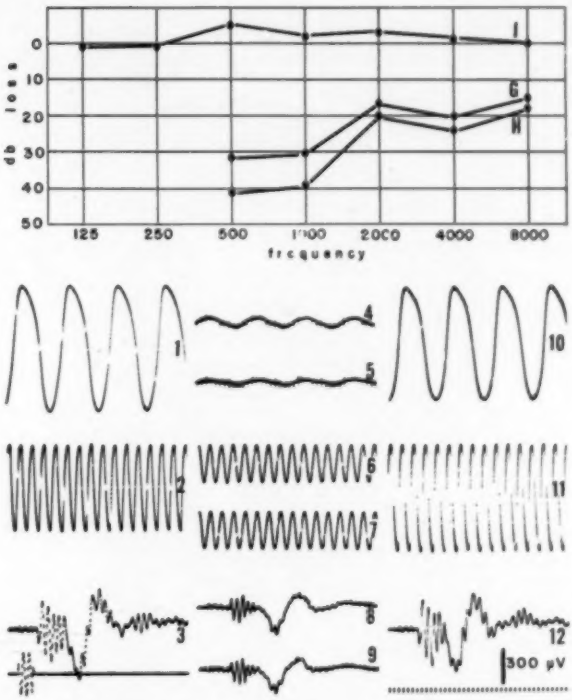

Fig. 8. Cat A-458. Effect of fenestra ovalis following fixation of stapes with 30 gm. Ossicular chain was not damaged. Record 1, reference amplitude of CM for 1,000 c.p.s. sine waves at 67 db. above threshold. Record 2, reference for 4,000 c.p.s. at 59 db. above threshold and Record 3, reference of AP for 8,000 c.p.s. tone pips at 71 db. above threshold. Curves for thresholds of CM and other records represent the following: Fixation of stapes with 30 gm., Curve G and Records 4, 6 and 8. After fenestra ovalis, Curve H and Records 5, 7 and 9. Removal of weight, Curve I and Records 10, 11 and 12. Notice that amplitude of CM for 4,000 c.p.s. is larger than the reference by 1.8 db.

4. Removal of Incus and Fixation of Stapes.

Fig. 9 is a freehand drawing of the ossicular chain after removal of incus and creation of the fenestra ovalis. As demonstrated before, removal of incus alone produced a considerable loss in thresholds and maximum voltage of both CM and AP. After removal of incus and fixation of stapes, the impairment exceeded 50 db. loss for all frequencies. In

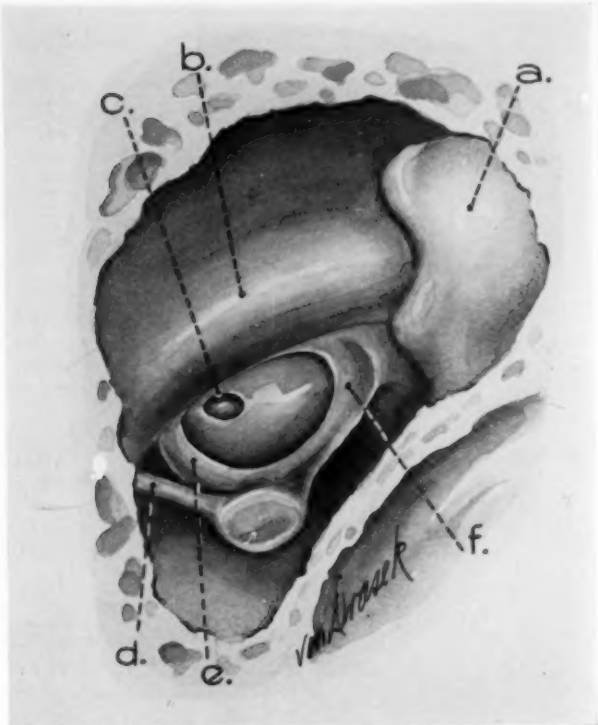

Fig. 9. Freehand drawing of ossicular chain after removal of incus. For simplicity, hook for mechanical fixation was not included. a. malleus; b. facial canal; c. simplified fenestra ovalis; d. tendon of stapedius muscle; e. posterior crus of stapes; f. anterior crus of stapes.

general, this result was favorably modified by the fenestra ovalis.

Changes in thresholds of CM of a representative case are illustrated in Fig. 10. *Curve J* shows the threshold shift after fixation of stapes alone, and *Curve K* that after removal of incus alone. When removal of the incus was followed by fixation of the stapes thresholds shifted to *Curve L.* After the fenestra ovalis was created, thresholds improved to *Curve M*; and when the fenestra was enlarged, thresholds showed

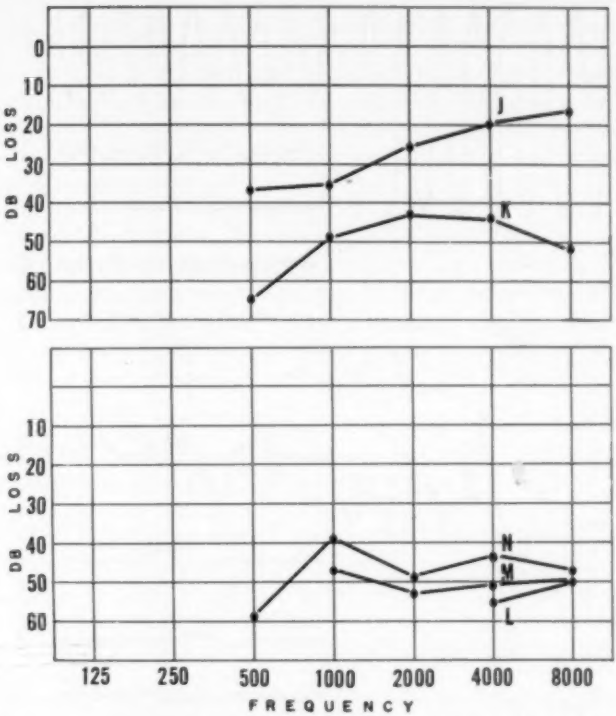

Fig. 10. Cat A-455. Effect of fenestra ovalis on thresholds of CM after fixation of stapes and removal of incus. Fixation of stapes with 30 gm., Curve J. Incus removed without fixation of stapes, Curve K. Incus removed plus fixation of stapes with 30 gm., Curve L. Curve M, fenestra ovalis plus incus removed and stapes fixed. Curve N, the fenestra was enlarged twice.

further improvement, *Curve N*. Final losses exceeded the 40 db. level.

Threshold shift of AP produced by fixation of the stapes and removal of the incus was also favorably modified, but the final loss was about the 60 db. level.

Changes in amplitude of both CM and AP can be estimated from the records presented in Fig. 11. The fenestra ovalis improved the losses produced by fixation of the stapes and

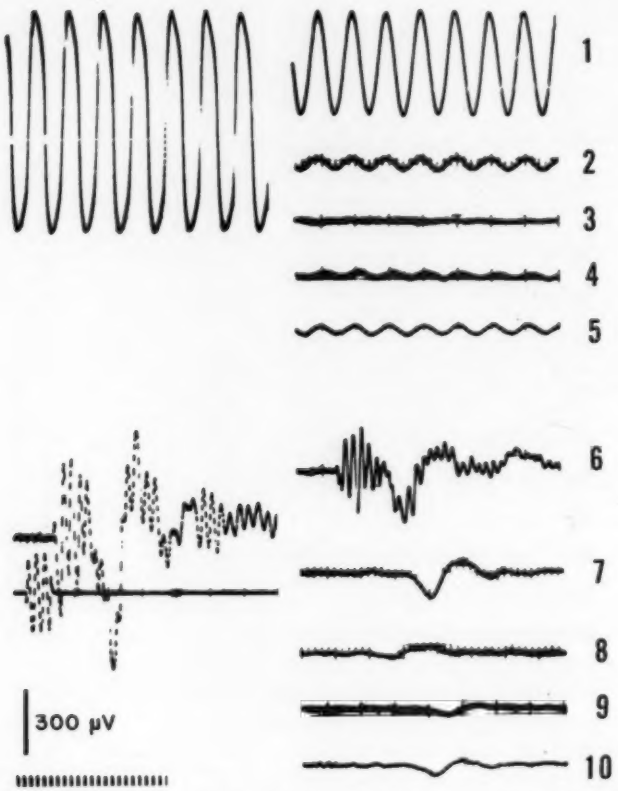

Fig. 11. Cat A-455. Effect of fenestra ovalis on amplitude of CM and AP. The records on left column are reference, 2,000 c.p.s. sine waves at 74 db. above threshold and 8,000 c.p.s. tone pips at 76 db. above threshold. Records 1 and 6, fixation of stapes with 30 gm. Records 2 and 7, removal of incus without fixation of stapes. Records 3 and 8, removal of incus and fixation of stapes. The hump in Record 8 is an artefact. Records 4 and 9, fenestra ovalis plus incus removed and stapes fixed. Records 5 and 10, the fenestra ovalis was enlarged twice.

removal of the incus by a few decibels. Nevertheless, the losses were 90 per cent or more of the reference.

When the sound stimuli were applied through the attic instead of the external ear the losses already described were sometimes decreased by a few decibels. A similar effect was

obtained by removing both malleus and tympanic membrane or by creating a perforation in the tympanic membrane.

Commentary. The losses produced by fixation of the stapes and removal of the incus were definitely decreased by a fenestra ovalis; however, the final loss remained larger than 40 db. As in the previous series these findings do not support the proposition of Rosen.[10,11]

The further improvement that was observed after removal of malleus and tympanic membrane, or after creating a perforation in the tympanic membrane, or when sound was introduced through the attic is due to the same condition: that is, elimination of attenuating effect produced by the presence of malleus and tympanic membrane.

The improvement of cochlear responses by the fenestra ovalis after fixation of the stapes and removal of the incus is more difficult to explain. When the stapes is fixed and the incus removed, incoming sound has access mainly to the round window. In other words, stiffness and frictional resistance are added to the stapes and, furthermore, mobilization of inner ear fluids is largely reduced because of the blocking effect. Now, the fenestra ovalis produces a stream of perilymph which fills the oval window niche, thereby the surface of perilymph reestablishes the area of this window. Inner ear fluids and fluid in the oval window niche make a continuous medium through the fenestra ovalis.[8] As a consequence the blocking of the oval window is eliminated, and stiffness and frictional resistance no longer play a role at this level. The fenestra ovalis seemed to produce the same effect as in the series where the incus was removed, but the stapes was not fixed. In both series the incoming sound has access to both windows and their counteractive effects will largely depend upon their phase relation.

In the series where the stapes was fixed and ossicular chain remained intact, the fenestra ovalis has no favorable effect, because sound is mainly conducted through on intact but overloaded ossicular chain. This overloading is not modified by the fenestra ovalis.

F. Final Remarks.

The proposition of Rosen[10,11] that the transformer action of the middle ear mechanism is a *sufficient* but not a *necessary* condition for normal hearing, can not be supported by these and previous experiments.[12] The statement of Rosen is based upon his experience with some cases of otosclerosis which recovered normal, or nearly normal, hearing after the fenestra ovalis operation, whether the incus was removed or not. We must seek an explanation for this finding.

The experience of Goodhill[8] with 50 cases of fenestra ovalis was that the procedure is unsatisfactory and the gains in auditory threshold are not only temporary but also lower than those obtained by stapes mobilization. As far as we know, Goodhill[8] and Scheer[16] have not reported any case of so-called normal or near normal hearing after the fenestra ovalis operation.

The present status of the fenestration operation leads to one explanation of the results claimed by Rosen.[10,11] According to Davis and Walsh[27] the average loss in threshold after the fenestration operation is 27 db. An additional gain of 6 db. may be obtained when incoming sound reaches both windows in suitable conditions of intensity and phase, as demonstrated by Wever[22] in the cat. Consequently, the lowest hearing level which can be expected after eliminating the transformer action by the fenestration operation is 20-21 db. The casuistics of Rosen[10] with fenestra ovalis showed that 26 per cent of the cases reached the 20 db. hearing level. The explanation of this result is obscure because, assuming the most suitable condition, the hearing level after fenestra ovalis should be about 35 db., of which 20 db. corresponds to loss of the transformer action and 15 db. to attenuation of incoming sound by the tympanic membrane and malleus. Experimentally, our results confirmed this theoretical calculation. The hearing level in the cats was 40 db. or more. Practically, in cases of otosclerosis, Goodhill[8] and Scheer[16] demonstrated that the fenestra ovalis operation does not improve hearing to better levels than the fenestration operation. Further improvement is due to the nature of the audiometric zero.[22] The reference

zero for audiometer calibration of the American Standard specification, represents the *average* auditory threshold of a mass survey. Consequently it is not surprising that some cases of otosclerosis present a remarkable recovery after either the fenestra ovalis operation or the fenestration operation. These cases belong to the group of subjects whose auditory thresholds are better than the audiometric average.

SUMMARY.

The concern of the present study was to investigate the effect of the fenestra ovalis operation on the transformer action of the middle ear mechanism.

Measurements of cochlear responses with bulla open or closed, injury of ossicular chain and simple mechanical fixation of stapes confirmed the results of previous investigators.

The fenestra ovalis, with a normal ossicular chain, produced only minor changes in cochlear responses, mainly in low frequencies.

Disarticulation of incudostapedial joint or removal of incus produced a threshold shift of 40 db. or more for cochlear microphonics and about 55 db. for action potentials. These losses were not essentially modified by a fenestra ovalis.

Simple mechanical fixation of stapes by attaching a 30 gm. weight produced a threshold shift in cochlear microphonic responses of 15 to 20 db. for high frequencies, 30 to 40 db. for middle range and no responses for low tones. The threshold shift of action potentials was about 16 to 20 db. This impairment may decrease or increase by 5 to 10 db. after fenestra ovalis.

Simple mechanical fixation of stapes with a 30 gm. weight plus removal of incus produced a threshold shift of 50 db. or more for both CM and AP. When this was followed by fenestration of the footplate a substantial recovery occurred, but the final loss was greater than 40 db.

The results indicate that the fenestra ovalis can not restore the reference or normal cochlear responses once the trans-

former action of the middle ear mechanism has been altered; therefore, the proposition of Rosen,[10,11] that "the transformer action of the intact ossicular chain is a sufficient but not a necessary condition for normal and near-normal hearing," is not supported by these experiments.

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UNIVERSITY OF MICHIGAN MEDICAL CENTER.

The annual Otolaryngology Conference at the University of Michigan will be held April 16, 17 and 18, 1959, under the direction of Dr. James H. Maxwell, Chairman of the Department of Otolaryngology.

Applications may be addressed to the Department of Postgraduate Medicine, University Hospital, Ann Arbor, Mich.

OTOLOGIC EVALUATION IN CLEFT PALATE PATIENTS.*†

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Chicago, Ill.

The increasing concern for the complex and many faceted needs of the child with a cleft lip and palate, particularly in the domain of speech disorders, has necessitated the organization of a carefully designed integrated program of diverse professional talents striving toward a common goal—effective care on a longitudinal basis to obtain superior functional results. The otolaryngologist, in particular, is possessed of the proper grounding in the surgical anatomic and physiologic nature of the contiguous structures to render a most valuable service in the total rehabilitation of such a patient.

Since good hearing is essential to learning to speak, it is obvious that any hearing loss due to diseases of the ear is an obstacle to the patient's acquisition of good speech and is of primary concern to all who are engaged in the care of the cleft palate patient. The split in the velum alters physiologically the muscles related to the Eustachian tube, thus making the child vulnerable to frequent attacks of otitis media.

The tonsil and adenoid problem, so often the subject of controversy in the case of a normal child, deserves judicious evaluation when the child has a cleft palate since the lymphatic structures are an integral component of the velopharyngeal mechanism for the development of normal speech.

Congenital deformities of the external ear and nose, with resultant nasal obstruction, as well as the type of cleft and status of the patient, may play a significant role in the final analysis of the auditory state; however, the management of the multiple phase problem of auditory deficiency relative to

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‡Figures and photographs are from the files of the Cleft Palate Center of the University of Illinois, College of Medicine.

the condition of a cleft palate is mainly one of hearing loss. It is essential to know whether the loss of hearing is progressive and whether the speech development will be restricted by the hearing deficit.

The purpose of this paper is to report the results of a survey of the ear pathology and audiological findings in patients with clefts of the lip and palate, and to analyze the factors related to the pathogenesis of ear disease in this congenital anomaly.

HISTORICAL.

In 1878, Alt[1] reported on the "Cure of Deafmutism by Successful Treatment of Otorrhea and Congenital Cleft Palate." Thorington,[2] in 1892, reported a case of "almost total destruction of the velum palati corrected by an artificial soft palate, producing not only greatly improved speech, but an immediate increase of audition." Then in 1904, "drainage of milk through the ear in an infant with congenital cleft palate" was reported by Variot.[3]

The importance of good hearing in the phonetic rehabilitation of cleft palate patients was recognized early. In 1893, Gutzmann[4] observed that about half of his cleft palate patients had hearing disturbances which accounted for a frequent failure of speech therapy. Lannois[5] was probably the first to approach the problem of the status of the middle ear relative to cleft palate in 1901. Brunck,[6] in 1906, emphasized the need for a thorough otolaryngological examination in the phonetic correction of cleft palate patients because of the high percentage of inflammatory changes involving the upper airways and middle ear of these patients. Introducing the term "submucous cleft palate," and making a thorough investigation of this congenital anomaly, Kelly,[7] an otolaryngologist, in 1910 reported that 15 of 19 cases had ear difficulty associated with nasal catarrh. Rendu[8] associated cleft palate with congenital atresia of both external auditory canals and rudimentary auricles in 1912. Borel,[9] in her study on the physiology of phonation and speech therapy in cleft palate

patients, discussed otogenic phonetic disturbances, their correction and auditory re-education.

Pagnamenta[10] made an analysis of 150 postoperative cleft palate patients, and found that 30 per cent had hearing loss; however, he also observed that the severity of the cleft was parallel to the increase in severity of hearing loss. Seeler[11] stressed the importance of systematic speech therapy in cleft palate patients directed toward improving the efficiency of the palatal and tubal musculature, and the avoidance of persistent closure of the tube. Segre[12] studied the pressure changes in the middle ear of cleft palate patients during respiration and deglutition and maintained that in these patients the tubal opening has a paradoxical behavior—usually opens and closes during swallowing. Opposite conclusions were reached by Meissner,[13] who made an analysis of 213 cleft palate patients whose ages varied between 10 and 35 years. He found hearing disturbances in 27 per cent of his cases, but only 17 per cent of them had perfectly normal ears. The basis for these findings is a persistent closure of the Eustachian tube due to physiopathologic changes in the velotubal musculature. No relationship was found by Meissner between ear pathology and the severity of the cleft.

Beatty,[14] in dealing with pre- and postoperative management of cleft palate patients, recognized that seven per cent of his patients had infections of the ear or sinuses while under surgical observation. He pointed out how remarkable is the small percentage of ear and sinus disease in these patients, considering the disturbance of normal physiology of the nasal and oral cavities, often in association with malnutrition, dehydration and improper feeding methods.

More recently, Sataloff and Frazer[15] analyzed 30 children with cleft palate, and related the very high incidence of ear pathology and hearing loss (90 per cent) to hyperplasia of tonsils and adenoids. They suggested early adenoidectomy in infancy to preserve the hearing. Nassy,[16] of the Netherlands, studied 70 children and 40 adults with cleft palate and found that 61 per cent of them had hearing disorders and ear pathology. He suggests a disturbance of the function of the

Eustachian tube and that the frequency of ear disorders depends on the size of the cleft. He made a plea for early closure of the cleft, speech training and regular treatment of ear, nose and throat pathology. Halfond and Ballenger[17] analyzed the audiological and otological findings of 69 cleft palate patients and found that 50 per cent or more have hearing loss; however, no definite relationship could be established between hearing loss and the type and width of the cleft, surgical or non-surgical closure, nasal pathology, or hyperplasia of lymphoid tissue.

METHOD OF APPROACH TO ANALYSIS.

This study was carried out over a period of eight years and the data were derived from a study of hundreds of patients with clefts of the lip and palate. Four hundred and one of these individuals received a complete otolaryngological examination, and constitute the basis for this investigation and presentation.

The otolaryngological examination included the following survey:

A. History pertaining to:

1. Previous ear disease.

2. Age of first attack and frequency of ear infection.

3. Frequency of upper respiratory infections.

4. Frequency of sore throat (tonsillitis).

5. Relationship of upper respiratory infection and sore throat to ear infection.

6. Surgical removal of tonsils and adenoids, age of operation and significance relative to ear infection.

7. Presence of allergic factors of the upper head space.

8. Relationship of growth of individual to ear infection.

9. Contagious diseases and their relationship to ear infection.

10. Closure of the palate and the relationship to ear infection.

11. Insertion of a speech aid and the relationship to upper respiratory infections, sore throat and ear infection.

12. Hearing loss, onset and course.

B. Otological evaluation:

1. Configuration of auricles.

2. Patency and configuration of external auditory canals.

3. Tympanic membranes—

a. Landmarks and light reflex.
b. Evidence of retraction.
c. Scarring.
d. Perforations (site and size) and
e. Nature and amount of secretion.

C. Rhinological evaluation:

1. External configuration (dorsum, alae, columella, nares).

2. Condition of the vestibule.

3. Septal deformity (deviations, ridges, spurs).

4. Color of mucosa and size and resilience of turbinates.

5. Presence of abnormal secretions.

6. Patency of airway.

D. Pharyngolaryngological evaluation:

1. Type of cleft palate, width, and condition of adjacent tissues.

2. Neuromuscular function of velum and pharynx.

3. Presence, size, site, and condition of tonsils and adenoids.

4. Relationship of tonsils to movement of soft palate.

5. Relationship of tonsils to dimension of oro-pharynx.

6. Relationship of nasopharyngeal lymphoid tissue and nasal obstruction.

7. Evidence of laryngeal anomalies.

8. Size and position of tongue (glossoptosis).

9. Configuration, color and movement of pharyngeal and laryngeal structures.

10. The airway.

E. Laboratory procedures:

1. X-ray studies of mastoids (Schuller-Law, Stenver, Towne and Mayer's view) and sinuses (Caldwell, Water and laterals) was carried out when pathology was suspected.

2. Laminographic studies of the nose and nasopharynx when indicated.

F. Functional examination:

1. Vestibular evaluation performed in presence of severe or perceptive hearing loss.

2. Hearing evaluation in patients with—

a. Congenital anomalies of the ear.
b. History of recurrent ear infection.
c. Evidence of middle ear pathology.
d. History of contagious diseases that might relate to the ears.
e. Clinical evidence of inner ear dysfunction.

3. The hearing evaluation included—

a. Conversational and whispered voice.
b. Tuning forks.
c. Pure tone audiometry.
d. Speech reception threshold and discrimination tests (binaural in free field and monaural with ear phones) when advisable.

Hearing evaluation in preschool children was performed by conditioning the child to execute a certain movement when pure tones, the name of toys, or low ("go") and high pitched ("sh") sounds were transmitted to him through a loudspeaker or ear phones. By transmitting these sounds at different loudness levels a fairly accurate hearing evaluation could be made. If a child was severely deaf, reflexes were studied when producing very loud noises (tom-tom, bells, whistles, etc.). In instances of severe mental retardation, or in brain injured children, the responses to auditory stimulation during electroencephalography were observed. The psychogalvanic skin resistance test was employed only as a control when advisable.

To further document data referable to growth and develop-

ment of the head associated with this anomaly, cephalometric roentgenography is employed. The instrument for oriented cephalometric roentgenography consists of a firmly-based head-positioning device and two X-ray tubes in fixed relationship to the head-positioner (see Fig. 1). This arrangement provides a constant position of the head in relation to the

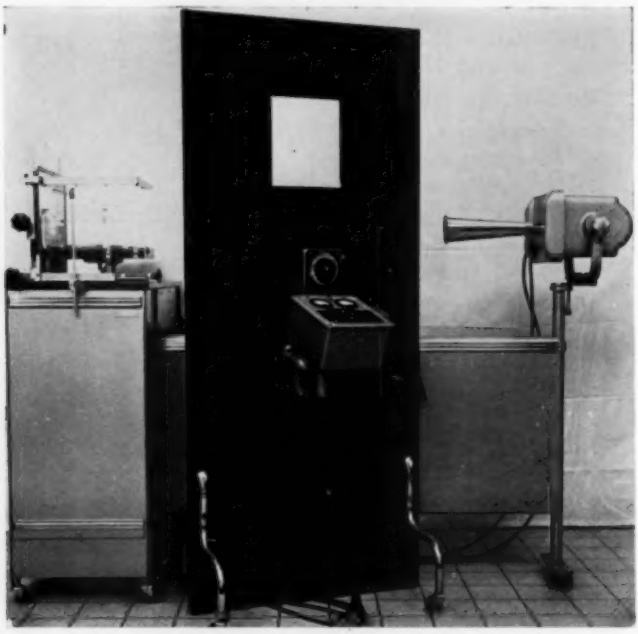

Fig. 1. Specially designed cephalometer. The X-ray tube for the frontal film is concealed within the cabinet betneath the head holding device.

source of X-rays; therefore, it becomes possible to reproduce the same lateral and postero-anterior views of the head at desired intervals. The resultant films are then placed on a trans-illuminated tracing table and covered with thin tracing paper. The bony structures visible on the film, as well as the outlines of the soft tissue profile, the pharynx, soft palate and the tongue are traced onto the paper. Where it is desired

to study the changes incident to growth or the movements during phonation, one tracing is superimposed on the other. The roentgenographic studies are facilitated by sedating the younger children.

This survey does not represent a research project to prove a certain thesis. The objective is to report the ear pathology and audiological findings in 401 individuals with cleft lips and palates observed in a period of eight years; furthermore, the study was not strictly limited to observations of diseases of the ear, nose and throat. According to the concept of *total patient care,* and in order to stimulate interprofessional understanding of the defect, the ear pathology was related to the genetic heritage, metabolic climate, growth and development pattern, and to the surgical and non-surgical modalities of rehabilitation.

ANOMALIES OF THE EAR IN CLEFT PALATE PATIENTS.

The association of cleft palate and other physical malformations, particularly due to arrested development, has been frequently observed; however, as far as the congenital anomalies of the ear are concerned, very few cases have been reported, and no impression of its average incidence of occurrence has been given.

Fogh-Andersen[18] in a study of 1013 patients with cleft lip or cleft palate reported severe malformations in more than ten per cent, with three or more rare abnormalities present in a great number of infants. He observed also a patient with cleft lip and palate associated with cranioschisis and atresia of the auricles, a child with cleft palate, atresia of the auricles and syndactilism, and a case of cleft lip with malformation of the auricles. Ivy[19] reported about 11 per cent of other congenital anomalies in the cleft lip or cleft palate patients observed in Pennsylvania.

Among the 401 patients processed through this study, 62 (15 per cent) exhibited other congenital anomalies (Scheme I). The number of instances of mandibular micrognathia and upper and lower limb malformations is considerable. Twelve of the patients presented the syndrome of Pierre

Robin (hypoplasia of mandible, cleft palate, glossoptosis, respiratory difficulty and malnutrition).

The patients with mandibular micrognathia and the majority of the other malformations presented a cleft of the hard and soft palates (53 per cent of 62 cases). Fogh-Andersen[18] divided his cases into "hereditary" and "solitary," ac-

SCHEME I.

CONGENITAL ANOMALIES IN CLEFT PALATE PATIENTS.

Anomaly	Cases	Types
1. Anomalies of the Head	2	Acrocephaly, microcephaly.
2. Asymmetry of the Face	3	
3. Anomalies of the Eye	6	Corneal opacity, microphtalmia, iris colobomata, retrolental fibroplasia, optic atrophy, ptosis of eye-lids, atresia of naso-lacrimal duct, strabism.
4. Anomalies of the Ear	8	See Scheme II.
5. Choanal Atresia	1	
6. Mandibular Micrognathia	16	Pierre Robin's syndrome was seen in 12 of these cases.
7. Tracheal Stenosis	1	
8. Anomalies of the Neck	3	Klippel-Feil syndrome, branchial cyst.
9. Anomalies of the Heart	4	Absence of interventricular septum, patent ductus arteriosus.
10. Anomalies of the Rectum	1	
11. Anomalies of Genitalia	5	Hydrocele, cryptorchidism, phymosis.
12. Anomalies of Upper Limb	9	Adactilism, syndactilism, webbed fingers, ankylosis of interphalangeal joints, club hands.
13. Anomalies of Lower Limb	13	Adactilism, syndactilism, webbed toes, club feet, metatarsus varus, calcaneous valgus, absence of left foot.
14. Hemangiomas	4	Observed on the tongue, chest, back and buttock.
15. Mongolism	3	

cording to a hereditary link that could be substantiated. In his analysis he also pointed out that the majority of patients with lip involvement are supposed to be hereditary, while "in the isolated palatal cleft there is a considerable admixture of non-hereditary cases." In our series, although numerically not so large, it was observed that only exceptionally were

other anomalies associated with cleft palate cases in which a hereditary relationship could be demonstrated. This corresponded to Fogh-Andersen's observations.

Anomalies of the ear were noted in eight of the cleft palate patients, or 2 per cent of all the cases, or 13 per cent of the associated anomalies. Mild anomalies, such as pointed ear,

SCHEME II.

ANOMALIES OF THE EAR IN CLEFT PALATE PATIENTS.

Anomalies of the Ear.	Associated Anomalies.
1. Deformity of the Auricles.	Cleft of the hard and soft palates, Klippel-Feil syndrome, anomalies of the heart and rectum.
2. Deformity of the auricles and stenosis of external auditory canals.	Cleft of the hard and soft palates, mandibular micrognathia.
3. Deformity of the auricles and displacement of the right external auditory canal.	Cleft of the hard and soft palates, mandibular micrognathia with Pierre Robin syndrome.
4. Microtia and stenosis of external auditory canal, right.	Unilateral cleft of the lip and palate, right.
5. Microtia, displacement and stenosis of external auditory canal, right.	Unilateral cleft of the lip and palate, left; asymmetry of the face, right; anomaly of the heart.
6. Microtia and atresia of external auditory canal, right, with stenosis of external auditory canal, left.	Cleft of the soft palate.
7. Microtia, displacement and atresia of external auditory canal, right, with stenosis of external auditory canal, left.	Cleft of the soft palate; asymmetry of the face, right; peripheral facial paralysis, right.
8. Atresia of external auditory canals.	Bilateral cleft of the lip and palate, optic atrophy.

lop ear, Darwin's tubercle were not included. The degree of involvement in the cases ranged from a moderate malformation of the auricle, atresia of the external auditory canals, to the more severe configurations of microtia, melotus, asymmetry of face, or peripheral facial paralysis (Scheme II).

It is of interest that three cases were associated with clefts of the hard and soft palates and two with clefts of the velum. The problem of the pathogenic relationship between cleft palate and anomalies of the ear deserves more consideration.

Independent of the exact mechanism of development of cleft lip and palate, the importance of the mandibular arch is fully recognized. According to the classical theory of fusion of nasal and maxillary processes, or the theory of mesodermal penetration, it seems that an arrest of development is significant in the pathogenesis of clefts of the lip and palate. In particular, the theory of non-fusion of the palatine processes is for most investigators still valuable to account for the origin of the clefts of the hard and soft palates. On the other hand, it is known that the external auditory canal develops from the first branchial groove and the auricle from the adjacent mandibular and hyoid arches. The Eustachian tube and tympanic cavity develop from the first pharyngeal pouch, while the malleus and incus are formed from Meckel's cartilage, and the stapes from Reichert's cartilage.

Among the cases with cleft palate, two patients are observed with unilateral microtia and homolateral asymmetry of the face (due to under development of the hemimandible), and two patients with bilateral deformity of the auricles and mandibular micrognathia. This association of mandibular, palatal and auricular anomalies seems to indicate an arrest of development involving primarily the first branchial arch. In fact, there is a definite parallelism between the formation of the mandible and the development of the auricle in its movement craniodorsally from its original caudo-ventral position.

Canick[20] has recently analyzed the embryology, pathologic anatomy, and etiology of cleft lip and palate. He concluded that the mechanism of embryogenesis is complex and that several factors, both inherent and environmental, influence the development of multiple anomalies. Genetic factors, dominant, recessive, incompletely sex-linked, and of reduced penetrance, have been considered. Environmental factors, such as vitamin and nutrient deficiencies, maternal diseases and age seem to play a part in teratogenesis. Duration, intensity and time of action of any agent seems to be of greater importance than the type of agent.

In the case of palatal and auricular anomalies, the normal

development of the first branchial arch remains incomplete or deviates. Hereditary factors and environmental agents may be the cause of this altered development; however, the observation that "solitary" cases of cleft palate and lip are more frequently associated with other anomalies; the greater incidence of association of anomalies in clefts of the hard and soft palates, the pathogenesis of which has often been related to micrognathia and nasal displacement of the tongue; the statistical data of no definite increase of other anomalies in relatives of cleft palate patients indicates the possibility of exogenous causes interfering with the early embryonic development. It is possible that induced mutations determine a disturbance of growth with the consequent occurrence of multiple anomalies due to arrest of development.

EAR PATHOLOGY AND HEARING DISTURBANCES IN CLEFT PALATE PATIENTS.

Several factors were seen to be clearly related to the pathogenesis of ear disease in cleft palate patients.

In Scheme III, the cleft palate patients are classified according to six groups, five of which are typical. The atypical group includes four cases of bilateral cleft lip and unilateral cleft palate, seven cases of unilateral cleft lip and bilateral cleft palate, two cases of unilateral cleft lip and cleft velum, one case of median cleft lip, bilateral alveolar ridge and cleft velum, four cases of unilateral cleft lip and submucous cleft palate and four cases of unilateral cleft hard and soft palate.

There is a male preponderance in the types of clefts involving the lip and a female preponderance in those involving only the hard and soft palates. The group of submucous cleft palate is too limited for any sex distribution. In the unilateral cleft lip and palate there is a definite prevalence on the left side.

The number of cases with ear pathology, unilateral or bilateral, totaled 184, or 45.8 per cent. Of these cases, 16.8 per cent were unilateral and 83.2 per cent bilateral. The distribution of ear disease as to sex strictly corresponded to

SCHEME III.

INCIDENCE OF EAR PATHOLOGY AND HEARING DISTURBANCES IN CLEFT PALATE PATIENTS.

Type of Cleft	Cases	Male	Female	Cases with Ear Pathology: Total	Unil.	Bilateral	Male	Female	Cases with Unil. and Bilateral Hear. Loss
1. Bilateral Cleft Lip and Palate	65	48	17	33 (50%)	6	27	25	8	32
2. Unilateral Cleft Lip and Palate	133	83	50	62 (46%)	15	47	37	25	54
	Rt. 48 Lt. 85			Rt. 24 Lt. 38					
3. Cleft Hard and Soft Palates	106	48	58	33 (31%)	5	28	15	18	30
4. Cleft of the Soft Palate	45	20	25	25 (55%)	2	23	13	12	20
5. Submucous Cleft Palate	30	16	14	22 (73%)	3	19	9	13	19
6. Atypical Cases	22	15	7	9 (40%)	—	9	6	3	3
Total	401	230	171	184	31	153	105	79	158
Percentage		57.4%	42.6%	45.8%	16.8%	83.2%	57.2%	42.8%	39.4%

SCHEME IV.

TYPE OF EAR PATHOLOGY AND HEARING LOSS IN CLEFT PALATE PATIENTS.

Type of Cleft	Pathol. Ears	Cong. Anom.	Rad. Mast.	Ferf.	Scar	Retr.	Alt. of Lust.	Pathol. Ears Tested	Normal Hearing	Mild Hear. Loss	Mod. Hear. Loss	Sev. Hear. Loss
1. Bil. Cleft Lip and Palate	60	2	1	18	21	12	6	56	7	36	13	—
2. Unil. Cleft Lip and Palate	109	2	2	27	23	34	21	88	6	57	22	3
3. Cleft Hard and Soft Palate	61	3	1	22	12	19	4	52	2	27	21	2
4. Cleft Soft Palate	48	2	1	12	10	12	9	38	3	20	14	1
5. Submucous Cleft Palate	41	—	1	9	14	11	6	38	4	20	9	5
6. Atypical Cases	18	—	—	5	—	8	5	16	10	2	3	1
Total	337	9	6	93	80	96	51	288	32	162	82	12
Percentage		2.7%	1.8%	27.6%	23.4%	28.4%	16.1%		11.1%	56.2%	28.4%	4.3%

that of the cleft palate patients. The total number of cases with definite hearing loss is 158, or 39.4 per cent.

In Scheme IV a more detailed analysis of the type of ear pathology and hearing loss is noted. Ear pathology is classified according to congenital anomalies, surgical procedures and severity of infection. The latter is divided according to the presence of dry or discharging perforations (evidence of previous or present purulent otitis media), scarring (evidence of repaired suppurative otitis media), retractions (evidence of repeated severe catarrhal otitis media), and alterations of luster (evidence of mild catarrhal otitis media). Each ear is reported only once relative to the greatest degree of pathology.

Perforations were noted in 27.6 per cent, scarring in 23.4 per cent, retraction in 28.4 per cent, alteration of luster in 16.1 per cent of the cases. It seems, therefore, that there is no significant preponderance of catarrhal or purulent otitis media in cleft palate patients. Central perforations prevailed as far as the site is concerned.

Not all of the cases with ear pathology could be tested audiometrically because of age, mental retardation or uncooperativeness. In some the audiogram was not reliable. Among 288 pathologic ears accurately tested, 11.1 per cent did not show any hearing loss, 56.2 per cent showed a mild hearing loss (less than 30 db.), 28.4 per cent showed a moderate hearing loss (between 30 and 60 db.), and 4.3 per cent showed a severe hearing loss (over 60 db.).

Perceptive loss of hearing was noted in five cases; all others were of the conductive type. In one case a severe unilateral perceptive hearing loss and a moderate mixed type of hearing loss in the opposite ear was observed in a patient who had mumps previously. In a brain injury child, the audiogram revealed a bilateral moderate hearing loss without any ear pathology. The same finding was noted in a deaf child due to previous meningitis; the vestibular test failed to reveal any response. In one case unilateral complete deafness, due to previous labyrinthitis secondary to middle ear disease was noted; no response was elicited to the vestibular test. In an-

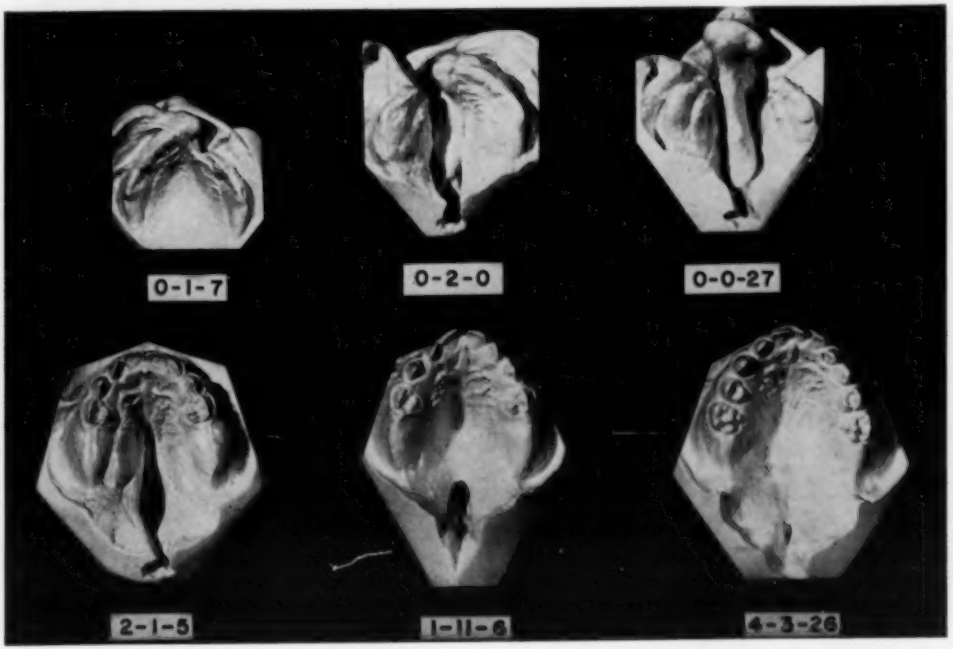

Fig. 2. Plaster cast reproductions of several varieties of unoperated clefts of the lip and palate.

other child a unilateral severe perceptive type of hearing loss was noticed, but no etiologic basis could be evinced.

The majority of cases revealed a conductive type of hearing loss with predominant loss in the low frequencies and usually bilateral with a similar pattern in both ears. A close relationship was noted between the degree of middle ear disease and degree of hearing loss. The severest cases of hearing loss were either perceptive or due to surgical procedures of

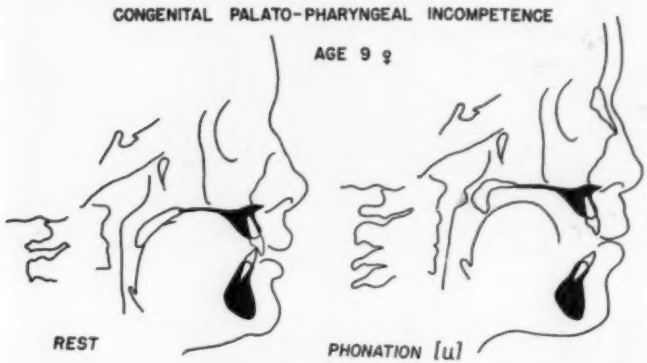

Fig. 3. Palatopharyngeal incompetence as evidenced by cephalometric roentgenographic analysis from lateral films obtained at rest and during phonation of the vowel u as in "boom." Note congenital shortening of the palate and inability of the velum to make contact with the posterior pharyngeal wall. The formation of Passavant's bar on the posterior wall of the pharynx is indicated in the stippled area.

the mastoid. Since conductive hearing loss, if not curable, is at least partially preventable, the role of the otologist in the follow-up of cleft palate patients is paramount.

INCIDENCE OF EAR PATHOLOGY ACCORDING TO AGE GROUP.

In subdividing the cases according to their age, expressed in years, it was apparent that the incidence of middle ear pathology followed a different pattern according to four groups which appeared strikingly uniform in their structure. Diagram I is very demonstrative.

In the group of cases below one year of age only 6 per cent

were found to have middle ear pathology. A definite increase to 27 per cent of ear disease was noticed in the group of pre-school children (between one and four years of age). A more amazing increase of ear disease was observed in the school children (between five and 13 years of age). subdividing the latter group into two (five to eight years and nine to 13 years) the incidence did not change substantially. In the limited number of cases over 13 years of age, the frequency of ear disease did not vary significantly. It seems, therefore, that a gradual increase of ear disease exists up to the school age and then persists at a plateau level.

In analyzing the cases that were followed over a long period of time there was a comparable increase of ear pathology in passing from the pre-school age to the school age. The contagious diseases, as well as the increased incidence of upper respiratory infections, are factors that tend to raise the percentage of ear pathology and hearing loss in a patient with previously altered anatomic and physiologic relationships, as exists in a child with a cleft of the palate, a repaired cleft or a cleft fitted with a prosthesis.

Beatty[21] reported that in his experience the majority of "well fed and well cared for" infants do not develop ear infection prior to the age for surgical closure of the palate.

The frequency of ear disease in school age children observed in this study is most significant and expresses in figures the higher incidence of ear pathology in cleft palate patients compared to the normal child. The values obtained in the School Surveys of the Hearing Conservation Program, which throughout the country average between 8 and 10 per cent, are used as controls. Values of 60 per cent of hearing impairment in cleft palate children in school age measure this difference beyond discussion, as evidenced in the charts (Scheme III and Diagram I).

INCIDENCE OF EAR PATHOLOGY ACCORDING TO TYPE OF CLEFT.

An analysis of Scheme I reveals that a different incidence of ear pathology exists for each type of cleft (see Fig. 2). Maximum frequency prevails for submucous cleft palate (73

per cent) and a minimum for clefts of the hard and soft palates (31 per cent); however, as was mentioned in the preceding paragraph, a definite difference of incidence, according to the age group, was seen and it is obvious that no comparison can be made between different types of clefts without considering the age factor.

In Scheme V the incidence of ear pathology in cleft palate

INCIDENCE OF EAR PATHOLOGY IN CLEFT PALATE PATIENTS ACCORDING TO AGE GROUP.

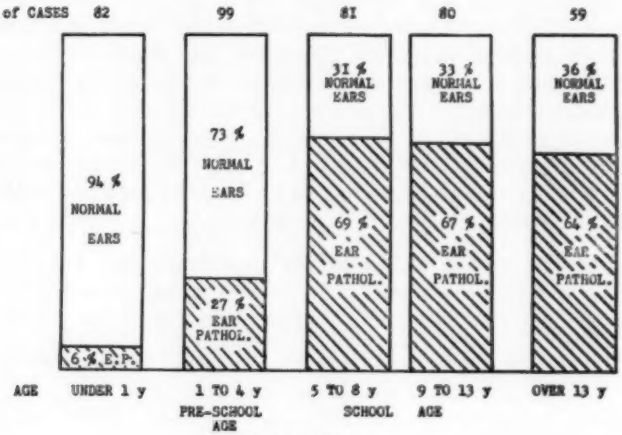

DIAGRAM I.

patients according to the type of cleft in the pre-school and school age is noted. The atypical cases are not considered, because the structure is not uniform.

It is quite significant that in the school age group the incidence of ear pathology, notwithstanding the small number of cases, is relatively uniform for each type of cleft. The average value being 68 per cent, variations exist between 62 per cent for clefts of the hard and soft palates and bilateral clefts of the lip and palate and 74 per cent for clefts of the soft palate.

The figures reported in the pre-school age group are too small to deserve consideration; however, one is justified in emphasizing the small incidence of ear pathology in this group for the clefts of the hard and soft palates (12 per cent of 33 cases). The reason for this relatively small frequency of ear pathology is not clear. This is probably related to a less distorted anatomical configuration of the head spaces and relatively greater intactness of the neuro-muscular mechanism of the Eustachian tube.

SCHEME V.

INCIDENCE OF EAR PATHOLOGY IN CLEFT PALATE PATIENTS ACCORDING TO TYPE OF CLEFT.

Type of Cleft	Pre-School Age (From 1 to 4). Total Number of Cases: 21. Cases with Ear Pathology	Cases with Normal Ears	School Age (From 5 to 13). Total Number of Cases: 156. Cases with Ear Pathology	Cases with Normal Ears
Average Values	27 %	73 %	68 %	32 %
1. Bilateral Cleft Lip and Palate	2 (25%)	6 (75%)	16 (62%)	10 (38%)
2. Unilateral Cleft Lip and Palate	11 (30%)	27 (70%)	35 (71%)	14 (29%)
3. Cleft Hard and Soft Palates	4 (12%)	29 (88%)	24 (62%)	15 (38%)
4. Cleft of the Soft Palate	6 (55%)	5 (45%)	14 (74%)	5 (26%)
5. Submucous Cleft Palate	—	1	17 (73%)	6 (27%)

Among the 62 cases of unilateral cleft lip and palate, 21 (33 per cent) showed unilateral or definitely more pathology in the ear opposite the side of the cleft, seven on the same side and the remaining, uniform, bilateral pathology. Of the 21 cases with greater contralateral pathology, six were untreated and 15 were postoperative. No definite relationship was noted in these cases with unilateral nasal obstruction.

RELATIONSHIP OF EAR PATHOLOGY TO WIDTH OF THE CLEFT.

According to Nassy,[16] the frequency of middle ear disorders in cleft palate patients depends on the size of the cleft. This

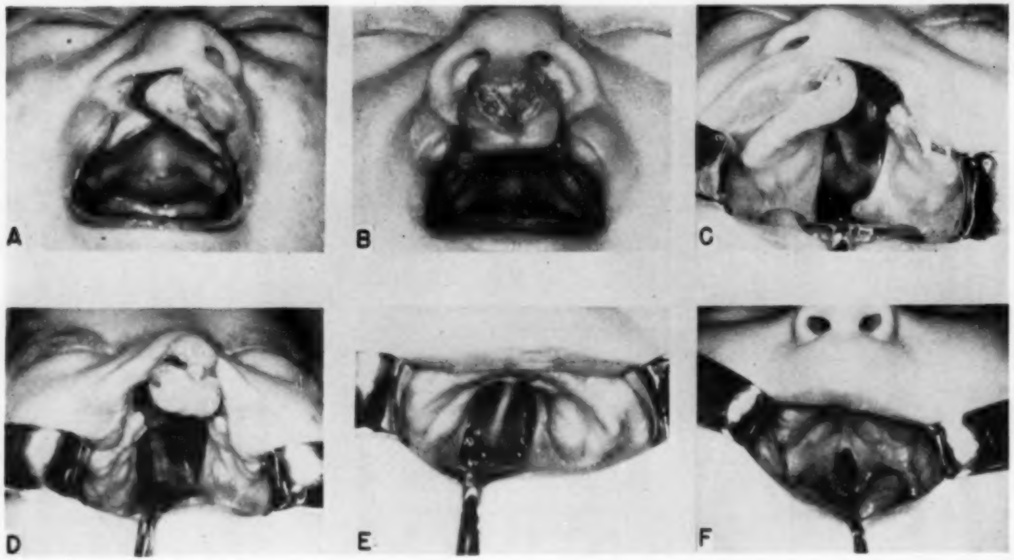

Fig. 4. Varieties of clefts of the hard and soft palates. A.—Unilateral cleft of the alveolar process with intact hard and soft palates. B.—Incomplete bilateral cleft of the lip with intact hard and soft palates. C.—Complete unilateral cleft of the lip, hard and soft palates. D.—Complete bilateral cleft of the lip, hard and soft palates. E.—Cleft of the hard and soft palates without involvement of the lip or alveolar process. F.—Cleft limited to the soft palate.

was not observed in an analysis of a group of school children with cleft palates in this study.

As the concept of width is purely subjective and variable with the dimensions of time, the closure of lip and orthodontic treatment, it is necessary to analyze children of a certain age group and with untreated palates. Borderline cases between "wide" and "narrow" were not considered. The different

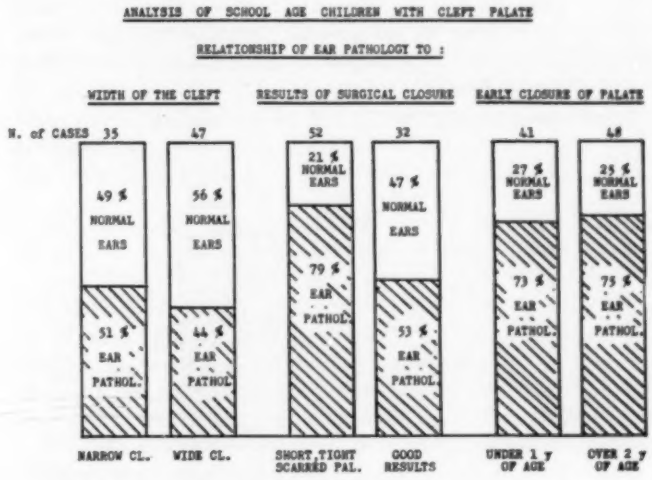

DIAGRAM II.

types of clefts are considered together as was demonstrated in the preceding paragraph. In the school age group the difference in frequency of ear pathology between the different types of clefts is insignificant.

Among 47 definitely wide clefts (not amenable to surgical closure, see Fig. 4) 21 (44 per cent) showed ear pathology and 26 (56 per cent) normal ears (see Diagram II). In the same age group among 35 narrow clefts (immediately prior to surgical closure) 18 (50 per cent) showed ear pathology, and 17 (49 per cent) normal ears; therefore, it does not

seem that the width of the cleft has a definite relationship to the frequency of middle ear disorders in cleft palate patients in the school age.

RELATIONSHIP OF EAR PATHOLOGY TO SURGICAL REPAIR OF CLEFT PALATE.

In Diagram III the relationship of surgical or prosthetical closure of cleft palate in pre-school and school children for the most important four typical clefts is evaluated.

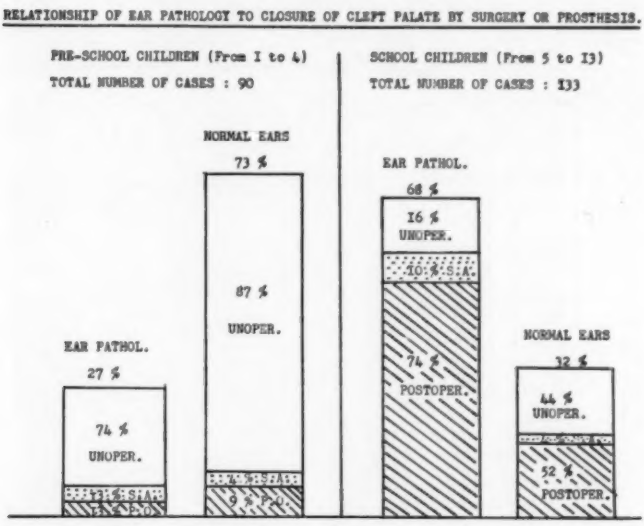

DIAGRAM III.

Both in the pre-school and school age groups there is a higher percentage of postoperative cases in the pathologic group than in the normal; however, the most significant finding is the definite increase of ear pathology in passing from the pre-school age to the school age group parallel to the increased number of postoperative cases. In the school age children with surgically closed palates, approximately 74 per cent had ear pathology (see Diagram III).

As other factors are involved in the difference of frequency of ear disease in the two age groups, further analysis of the importance of surgical closure in relation to ear pathology is made. Among the cases followed over a period of time, 16 developed otitis media in the school age after surgical repair and two after being fitted with a speech aid. Only six other untreated cases developed otitis media in the school age group. An analysis of the results of surgical repair among 52 cases in the school age with a palate that was short, tight and scarred, 41 (79 per cent) showed ear disease, and 11 (21 per cent) had normal ears. Among the 32 cases in the school age group with a good surgical repair, 17 (53 per cent) showed ear pathology, and 15 (47 per cent) had normal ears (see Diagram III). Twelve of the school age cases had more than five palatal operations: 8 (66 per cent) of them had ear pathology and 4 (34 per cent) showed normal ears.

The influence of early surgical closure was also considered: 41 of the cases of school age had palatal closure before one year of age; 30 (73 per cent) had ear pathology, and 11 (27 per cent) had normal ears. The percentage of ear pathology in children with a cleft palate closed after two years of age (when, according to Subtelny,[22] a leveling off of the dimensions of the cleft, maxillary and nasopharyngeal development has been reached) was approximately the same—over 48 cases, 36 (75 per cent) had ear pathology and 12 (25 per cent) had normal ears (see Diagram III).

Surgical closure of the palate appears to be an extremely important factor in the pathogenesis of middle ear disorders. The mechanism seems to be related to a process of atrophy, scarring and sclerosis of tubal muscles after surgery. The higher incidence of ear pathology in the cases with a scarred, tight palate compared with the good operative results accounts for this interpretation.

It has been said that simple anatomical closure of a palate without the formation of a velopharyngeal sphincter makes surgical treatment unsatisfactory. Certainly, the inadequacy of tubal musculature after surgery should be considered in the evaluation of a surgical repair of the palate; furthermore,

the opinion that early closure of the palate avoids secondary atrophy of palatal muscles and prevents otitis media, is not supported by this study. The dangers of early closure in relation to interference with centers of bone growth, and consequent serious disturbances of development of the bones of the jaw and face, and the high incidence of middle ear pathology, factors which are probably directly or indirectly related to each other, questions the validity of surgery at an early age, in many cases.

RELATIONSHIP OF EAR PATHOLOGY TO CLEFT PALATE PROSTHESIS.

Several otolaryngologists have the conviction that there is a relationship of cleft palate prosthesis with upper respiratory health and audition. No definite statement on the association of ear pathology to cleft palate prosthesis has ever been made.

Twenty-four of the cases in this study that were fitted with a speech aid were observed. Twenty of them were unoperated and four postoperative. The four postoperative and 13 of the unoperated cases showed ear pathology.

Clinical experience reveals a frequent association of inflammatory changes of the upper airways, lymphoid hyperplasia and middle ear pathology with cleft palate prosthesis. In most of these cases, however, an ill-fitting appliance or poor hygiene of the speech aid was noted. It is known that the size and shape of the segments of the appliance are highly individualistic. The contour of the palatal extension must conform strictly to the natural contour of the velar tags, and the bulb must adapt to the proportions of the patient's nasopharyngeal port. The level at which the bulb is placed in the nasopharynx is of utmost importance. The bulb must be reduced in size with the development of the patient's muscles. It must be pointed out that when a prosthesis is defective or the hygiene of the appliance is unsatisfactory, there is a disturbance of the physiology of the nose and nasopharynx with consequent dysfunction of the Eustachian tube.

RELATIONSHIP OF EAR PATHOLOGY TO NASAL DISTURBANCES IN CLEFT PALATE PATIENTS.

That nasal physiology in cleft palate patients is severely

disturbed, is quite apparent. The malformations of the alar cartilages with stenosis of the nares, the septal deflections with obstruction of the airway, and the abnormal communication of oral and nasal cavities are the main causes of this disturbance. The inspiratory and expiratory air currents, the air pressures, the humidifying, heating and purifying action of cilia and mucous blanket, the pH and bacteriology,

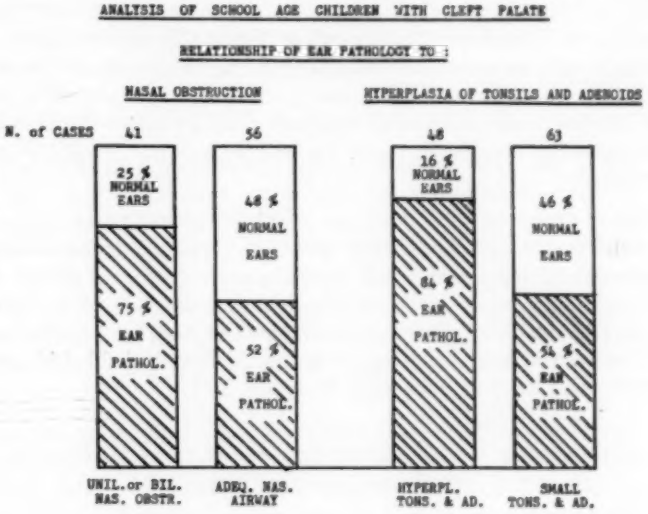

DIAGRAM IV.

must surely be modified in cleft palate patients as compared with the normal. As a consequence of altered physiology these children are more prone to frequent upper respiratory infections and vasomotor changes.

In an analysis of ear pathology related to nasal disturbances, a group of 41 school-age children with complete unilateral or bilateral obstruction of the nasal airway on an anatomical, catarrhal or vasomotor basis were studied. Thirty-one of them (75 per cent) showed ear pathology, while

10 (25 per cent) had normal ears. In a control group of 56 school children with an adequate bilateral nasal airway, 29 (52 per cent) had ear disorders and 27 (48 per cent) had normal ears (see Diagram IV).

RELATIONSHIP OF EAR PATHOLOGY TO HYPERPLASIA OF TONSILS AND ADENOIDS IN CLEFT PALATE PATIENTS.

The importance of adenoid growth and enlarged tonsils in the etiology of catarrhal and purulent otitis media in children has been stressed. On the other hand the significance of tonsils and adenoids for an adequate velopharyngeal closure in cleft palate patients is paramount. Inflammatory changes of lymphoid tissue in these patients should receive immediate conservative treatment and be controlled as promptly as possible.

In a group of 48 school-age children with hyperplasia of tonsils and adenoids, 40 (84 per cent showed ear pathology and eight (16 per cent) had normal ears. A control group of 63 school children with operated or unoperated clefts and with small tonsils and scanty amount of adenoid tissue, showed 34 cases (54 per cent) with ear pathology and 29 (46 per cent) with normal ears (see Diagram IV).

RELATIONSHIP OF EAR PATHOLOGY TO GENERAL FACTORS IN CLEFT PALATE PATIENTS.

Prematurity, malnutrition, dehydration, improper feeding methods and acute exanthemata appeared to be important factors in the development of severe purulent otitis media in cleft palate children. On the contrary, no definite relationship could be found between the incidence of ear pathology and multiple congenital anomalies.

DISCUSSION.

In an analysis of 401 patients with various types of clefts of the palate, it has been observed that a multiplicity of factors are responsible for the large percentage of patients with middle ear disorders and hearing disturbances.

Apart from congenital anomalies and a few general factors, such as genetic predisposition to ear pathology, resistance to infection and nutritional status, it is apparent that Eustachian tube dysfunction, primary or secondary to nasal and nasopharyngeal pathology, or surgical and non-surgical means of cleft palate closure, is the pathogenic basis of the greater majority of ear disorders in cleft palate patients than in normals.

A considerable emphasis has been placed on the fact that the inactivation of the velopharyngeal closure in the open cleft palate allows the food to enter the nasopharynx, and that atypical tongue habits cause continuous irritation and bathe the Eustachian tube openings with irritants.

The disturbed physiology and hygiene of the air spaces of the head is surely a factor in the pathogenesis of otitis media in cleft palate children. It is noteworthy how a relatively small percentage of these children under one year of age suffer from ear pathology. Lysozime and inhibitory activity of saliva and nasal secretions on bacterial growth must play an important role in these children who are free from infection, as well as the absence of environmental contact.

In no cases was any fluctuation noted of the tympanic membrane during respiration, as one would expect in a persistent patent Eustachian tube; rather, the kind of pathology that is described (alteration of luster, retractions and scarring) and the improvement obtained by inflation indicate that the physiopathology of the Eustachian tube in cleft palate patients is based on a persistent closure of the orifice.

It is of extreme importance to analyze the anatomy and physiology of a normal velum in order to understand the physiopathology of a cleft palate in relation to the function of the Eustachian tube (see Figs. 5 to 8).

The soft palate is a muscular hinge which is attached anteriorly at the posterior border of the hard palate by means of an aponeurotic structure and moves freely posteriorly. The muscles enter from the sides and interlace in the midline,

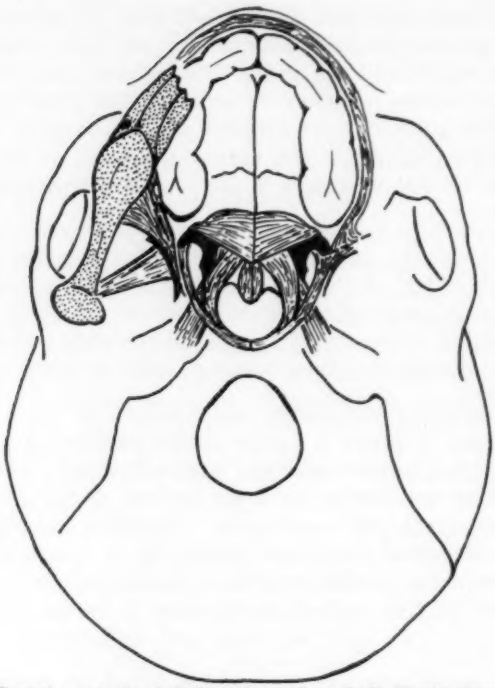

Fig. 5. Drawing of the inferior view of a skull illustrating the harmonious balance of intact musculature. Completeness of the musculature of the soft palate restrains the outward pull of the pterygoid muscles.

each pair forming a sling arching either upward or downward. The musculus uvulae fastens longitudinally all of these muscles in the midline without forming a real raphe.

Three pairs of muscles arch upward: the levator palati, the tensor palati and the pterygopharyngeus of the superior constrictor muscle of the pharynx. The levator veli palatini arises from the apex of the petrous bone and from the medial lamina of the cartilage of the auditory tube, enters the velum with its fibers spreading downward and medialward, and blending with those of the opposite side. The tensor veli palatini arises from the scaphoid fossa and the spina angularis of the sphenoid and from the lateral wall of the cartilage of

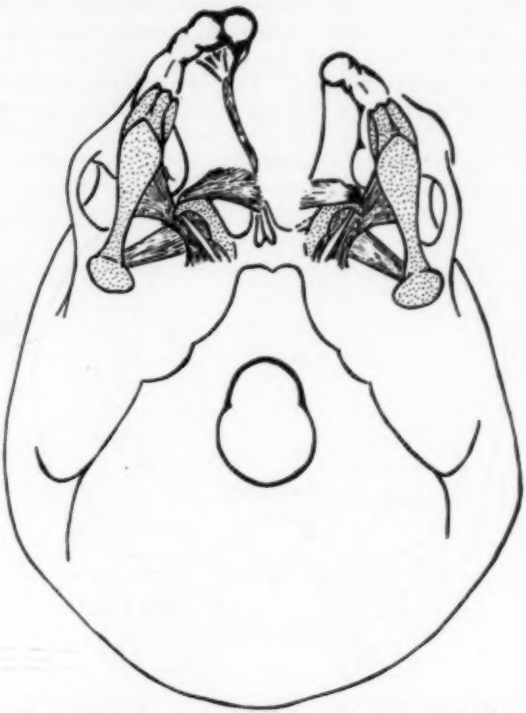

Fig. 6. Drawing of the inferior view of a skull to illustrate the loss of continuity of muscle structure as a result of a conbenital cleft. There is decreased restraint on the outward pull of the pterygoid musculature.

the auditory tube; its tendon, after winding around the pterygoid hamulus, is inserted into the palatine aponeurosis and the posterior border of the palatine bone. The pterygopharyngeus muscle arises from the pharyngeal raphe approximately 1.5 centimeters below the pharyngeal tubercle of the occipital bone. It runs outward toward the pterygoid plate of the sphenoid bone, one part being inserted on it, and the hamular process and the remaining fibers running medially to be inserted into the palatal aponeurosis.

Two pairs of muscles arch downward: the glossopalatinus in front forms the anterior pillars and the pharyngopalatinus

behind forms the posterior pillars. The glossopalatinus arises from the anterior surface of the soft palate, where it is continuous with the muscle of the opposite side and is inserted into the side of the tongue. The pharyngopalatinus arises from the soft palate and divides into two fasciculi. The an-

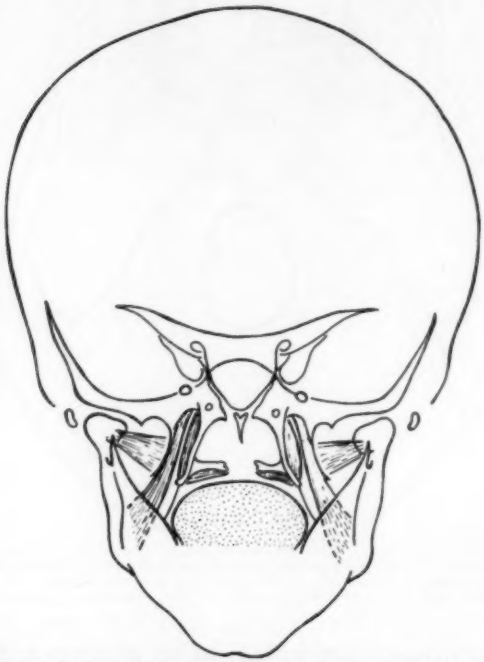

Fig. 7. Frontal view of the nasopharyngeal area illustrating: a loss of continuity of the tensor veli palatini muscles as a result of the cleft; the outward pull of the internal and external pterygoid muscles; the patent embryonic suture on both sides of the body of the sphenoid; the tongue, represented by the stippled area; the pterygo mandibular raphe extending downward on both sides of the tongue.

terior fasciculus is inserted into the posterior border of the thyroid cartilage and into the lateral and posterior wall of the pharynx. The posterior fasciculus joins the opposite muscle in the midline. An important muscular bundle connected with the latter fasciculus is the salpingopharyngeus muscle, which forms the salpingopharyngeal fold. It arises from the in-

ferior part of the auditory tube and blends with the posterior fasciculus of the pharyngopalatinus.

Podvinec,[23] in a recent study of the physiology and pathology of the soft palate, maintained that as the individuality of the different muscles becomes lost in the velum, it is reasonable to conclude that they are functioning together. He analyzes the functions of the soft palate as follows: *a.* to facilitate the transport of the bolus from the oral cavity to the pharynx; *b.* to close the nasopharyngeal port in swallowing and speech articulation; *c.* to elevate the larynx in swallowing and speech; *d.* to open the Eustachian tube during deglutition and yawning.

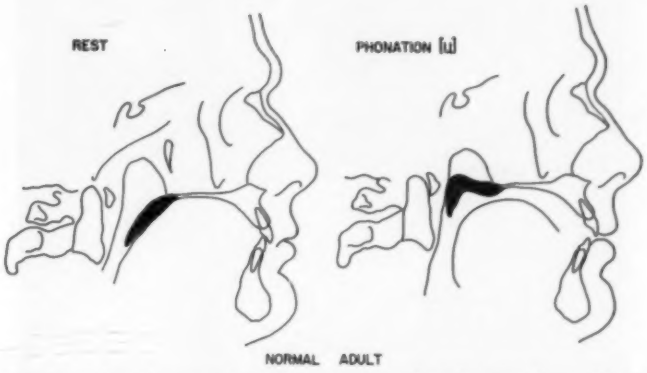

Fig. 8. Palatopharyngeal valving in a normal adult. Tracings of lateral cephalometric roentgenograms reveal the position of the soft palate within the nasopharynx. At rest the soft palate, outlined in black, rests on the dorsum of the tongue. During the sustained phonation of the vowell u the soft palate elevates to contact the posterior wall of the nasal pharynx.

The relationship between movements of the soft palate and opening of the Eustachian tube deserves more consideration. Perlman[24] in an authoratative study, reviewed the literature and analyzed with personal observations the movements and the nature of the physiological opening of the Eustachian tube. In phonation, the posterior lip of the torus tubarius is lifted passively during the elevation of the soft palate and floor of the tube by the levator palati, while the simultaneously rising salpingopharyngeus contributes actively to an addi-

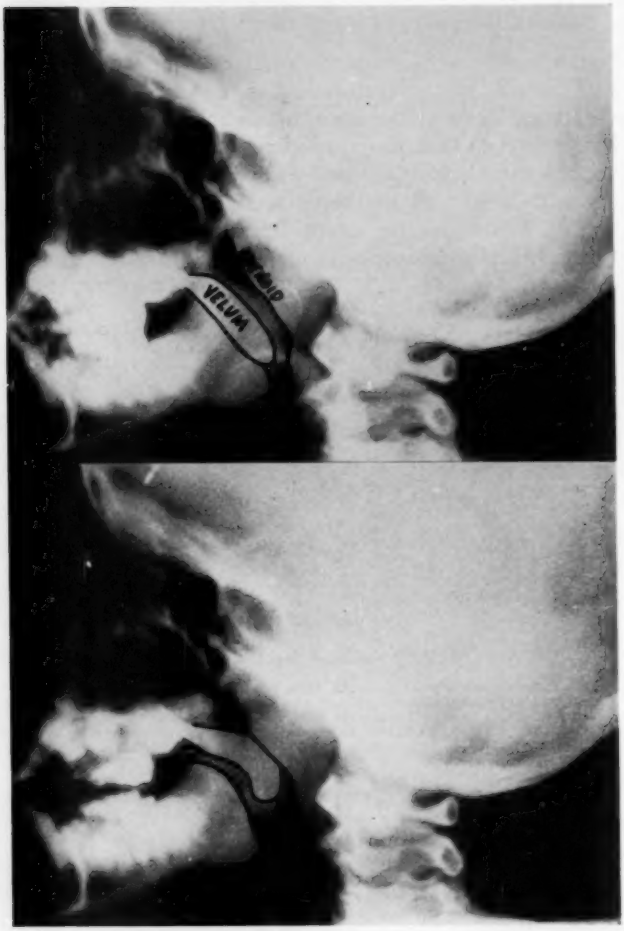

Fig. 9. Palatopharyngeal valving in a child with an intact adenoid mass. Note that during the sustained phonation of the vowel **u**, as revealed in the lower illustration, the soft palate makes contact against the adenoid projection into the nasopharynx rather than with the posterior wall of the pharynx.

tional displacement of the lower portion of the posterior lip. In deglutition, there is an active movement of the anterior and posterior lips of the torus tubarius, associated with elevation and lateral retraction of the soft palate and floor of the tube. Opening the tube during swallowing is not the result of simultaneous movements, but of a succession of movements of the tubal muscles. There is an initial widening of the orifice of the tube, determined by the movement of the inferior edge

Fig. 10.

of the posterior lip, due to active contraction of the rising salpingopharyngeus muscle. While the soft palate and floor of the tube are elevated by the action of the levator palati, there is an outward movement of the lateral portion of the orifice of the tube due to the tensor muscle which afterward, when the palate drops, determines an anterior displacement of the tube, producing a deep and round opening.

The Eustachian tube normally remains closed to shield the middle ear from pressure changes in the nasopharynx during quiet or forced respiration. Palatal and tubal activity, as produced in phonation, does not cause opening of the tube; nor does sound pressure in the nasopharynx during phonation. The tube as a rule opens during deglutition. Swallow-

ing liquid is most efficient in opening the tube. In the reflex opening during swallowing the tube opens more widely than in voluntary opening.

It is necessary to analyze the pathologic anatomy of cleft palate and the physiopathology of the Eustachian tube opening during deglutition. According to Veau,[25] if a cleft is formed the aponeurosis does not develop, because it represents the consequence of the posterior pulling of the muscular sling. The soft palate is, therefore, short, and the tendon of the

Fig. 11.

tensor muscle, which has an abnormal oblique and upward direction, is inserted mainly on the posterior edge of the hard palate. The action of the tensor palati on the velum is minimal in cleft palate; it may pull the velar tags forward and outward, causing the tips of the cleft uvula to point toward the midline. On the other hand, arising partly from the posterior border of the hard palate it should be able to open the Eustachian tube orifice. The activity of the levator palati becomes insignificant. When present its action, associated with the one of the divided pterygopharyngeus segment of the superior constrictor, is to open the cleft more widely.

The opening of the Eustachian tube orifice during degluti-

tion appears definitely impaired in a cleft of the palate. The levator palatini is unable to elevate the soft palate and floor of the tube. The swallowing synergy is disturbed, and no reflex opening of the tube by means of the tensor muscle can be elicited. The only active muscle in this mechanism is probably the salpingopharyngeus, which in some cases stands out like a band of muscular tissue on the lateral pharyngeal wall.

Veau[25] maintains that palatal and pharyngeal muscles have a normal volume in a cleft palate fetus; however, with age,

Fig. 12.

muscular atrophy develops secondary to the anatomical anomaly and inactivity, and the opening of the Eustachian tube will become more and more impaired. It is particularly after a poor surgical result that atrophy reaches its maximum; the velum is whitish, tight and immobile.

The idea that early closure would prevent muscular regression definitely fails to attain its goal when a poor result is obtained. In these cases the dysfunction of the Eustachian tube is considerable, and a high percentage of ear pathology is recorded. Even if a good surgical result is obtained with restoration of the velopharyngeal sphincter, the dysfunction

of the Eustachian tube is still great. The division of the hamular process, advocated by so many surgeons, will release the tension of the tensor veli palatini and permit medial displacement of the velar tags restoring the velopharyngeal closure; however, the function of the tensor will be altered into an elevator, and no further lateral displacement of the lateral wall of the tube will be possible. If a push-back or pharyngoplasty procedure is performed, the change of environment for palatal and pharyngeal muscles may result in a relative inactivity of the neuromuscular mechanism.

Fig. 13.

On the other hand the action of the superior constrictor should be noted. When compensatory hypertrophy of pharyngeal muscles develop and a considerable Passavant's ridge is seen, the medial displacement of the tubal cartilage and salpingeal folds unassociated with an anterior and outward shift of the tube impairs the opening of the Eustachian tube.

If a patient is fitted with a speech aid, there is a possibility of ill-fitting and poor hygiene as a cause of impaired drainage of secretion, chronic pharyngitis and hyperplasia of lymphoid tissue.

Nasal deformities were often found associated with altera-

tions of nasal mucosa on a catarrhal or vasomotor basis. In a certain number of patients, hyperplasia of tonsils and adenoids with accumulation of secretion in the nasal and nasopharyngeal cavities were observed. In these cases the already impaired function of the Eustachian tube orifice becomes desperate and persistent, or recurrent middle ear disorders with hearing loss are the rule.

Sataloff and Frazer[15] have advocated adenoidectomy in infancy at the time of the first palatal operation. After the

Fig. 14.

analysis of the multiplicity of factors involved in the middle ear disorders in cleft palate patients and the physiopathologic study of the Eustachian tube opening, it appears that adenoidectomy, in relation to speech rehabilitation, should be performed judiciously (see Fig. 9). Special techniques directed toward the removal of the lymphoid tissue surrounding the Eustachian tube orifices, either surgically or with the use of a radium applicator, should be employed, when possible, in order to maintain the integrity of the velopharyngeal closure.

Continuous otological study of cleft palate patients is of utmost importance. When middle ear disorders develop, the several etiologic factors should be considered and removed,

if possible. Immediate treatment of the ear, nose and throat conditions is paramount in these children. A hearing evaluation should be done as soon as possible. To repeat—"Good hearing is essential to good speech."

CONCLUSIONS.

1. Congenital anomalies of the ear are present in 2 per cent of all cleft palate patients and account for 13 per cent of associated anomalies to cleft palate. They appear to be due to an arrest of development without a definite genetic basis.

2. Forty-five per cent of cleft palate patients show definite evidence of ear pathology and 39 per cent have a definite hearing loss.

3. There is no sex prevalence in the frequency of ear pathology in cleft palate patients.

4. The middle ear disorders are predominantly bilateral with similar features in both ears. There is no significant difference in frequency between purulent and catarrhal otitis media.

5. The hearing loss is mild in more than one-half of the cases, moderate in about one-fourth of them. Only about 4 per cent have severe hearing loss. With the exception of five cases with a perceptive loss, all of the other cases have a typical conductive type of hearing loss with a similar pattern in both ears. Close relationship is noted between the degree of ear pathology and hearing loss.

6. The incidence of ear pathology is 6 per cent before one year of age, 27 per cent in pre-school children and 68 per cent in school children. The incidence appeared to level off at this period.

7. The frequency of ear pathology according to the type of cleft is strikingly uniform in school age children. There is a smaller incidence of ear pathology in the clefts of the hard and soft palates in pre-school age children. One-third of the cases with unilateral clefts of the lip and palate showed contralateral ear pathology.

8. No definite relationship could be evinced between the width of the cleft and ear pathology.

9. Surgical closure is related to a higher incidence of ear pathology in cleft palate children. A correlation is noted between velar activity and frequency of middle ear disorders. Early closure of the palate does not reduce the incidence of ear pathology.

10. Ill-fitting or poor hygiene of speech aids interfere with nasopharyngeal physiology and may result in middle ear disorders.

11. Nasal obstruction on an anatomical, catarrhal or vasomotor basis is a factor in the increased incidence of otitis media.

12. Hyperplasia of the tonsils and adenoids is intimately related to middle ear disorders in a group of cleft palate patients.

13. General factors such as prematurity, malnutrition and exanthemata surely predispose cleft palate children to a higher incidence of middle ear pathology.

14. The pathogenesis of middle ear disorders in cleft palate patients is primarily related to a tubal dysfunction. This dysfunction is definitely increased by all the above mentioned factors on a neuro-muscular or mechanical basis.

15. The role of the otologist in a cleft palate care program is of extreme importance. Continuous otologic vigilance of these children is a must. Audiograms should be repeated at regular intervals. Ear, nose and throat disease should be controlled immediately to prevent any further hearing impairment.

SUMMARY.

Otolaryngological implications in cleft palate patients have not been fully realized until recently. A survey of the available literature fails to reveal an extensive study of ear pathology in cleft palate patients; 401 patients with various types of clefts are thoroughly investigated in the otolaryngological

field and receive accurate audiological study. The anomalies of the ear associated with cleft palate are described, analyzed and discussed. The higher incidence of middle ear pathology in cleft palate children than in normals receive a quantitative measure in this study. The frequency of catarrhal and purulent middle ear infection is reported, as well as the frequency and nature of the hearing loss. The several factors related to these findings are discussed in detail in the light of the statistical values: age of the individual, type of cleft, width of cleft, surgical and non-surgical closure of cleft palate, nasal disturbances, hyperplasia of tonsils and adenoids, and general resistance. The pathogenesis of middle ear disorders appears to be due to a Eustachian tube dysfunction, altered on a neuromuscular basis by the above factors.

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PRACTICABILITY OF IMMEDIATE FENESTRATION AFTER STAPES MOBILIZATION FAILURE.*

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INTRODUCTION AND EVOLUTION OF THE PROBLEM.

The return to popularity of direct surgical attack upon the stapes for improving hearing in otosclerotic deafness came slowly. After reading Rosen's[1,2] first articles on stapes mobilization, I was skeptical, because I felt that most stapes fixed by an otosclerotic process would not mobilize, and if they were mobilized, fixation would quickly recur. Followup reports[3,4,5] confirmed my first objection to the procedure (a low percentage of good results), but other reports[6,7,8] refuted my second objection that results would be short lived; therefore, I decided to learn the necessary technique and acquire the necessary skill to practice this procedure. The idea of practicing a procedure which would result in disappointment to approximately two-thirds of the patients operated on was so unpalatable, however, that in November, 1955, I decided to work out a stapes mobilization technique which would lend itself to immediate Lempert fenestration in case of failure.

That is the background of the present study, begun in December, 1955, and continued with its interesting ramifications to the present.

The problem of surgical technique, the first to present itself, was not exceedingly difficult to solve, and is reported in the first part of this paper under technique and presentation of cases.

Establishing methods to determine accurately which stapes mobilizations were failures, and in which to proceed with a

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fenestration, was the second and greater problem. This problem involves the patient whose stapes mobilization is apparently unsuccessful at the time of operation, but whose hearing is found to have improved considerably over the preoperative level weeks or months later. In such a case, an unnecessary fenestration would have been done. Because of this the combined procedure was abandoned.

The second part deals with the attempt to determine the incidence of this special problem, to solve it by establishing a criterion of failure or success of stapes mobilization on the table, and to evaluate this criterion by postoperative follow-up of a series of cases to which it had been applied.

REVIEW OF LITERATURE.

Surgical attempts to improve conductive hearing loss by mobilization of the ankylosed stapes date from the work of Kessel[9] in 1876, when he tried to improve hearing loss resulting from infection by removing the drum, malleus, and incus. This method being unsuccessful, he later tried stapes mobilization and stapedectomy.[10] Boucheron[11] reported 60 cases in which he excised the posterior half of the drum, separated the incus from the stapes and mobilized the stapes. Miot[12] reported 200 cases of stapes mobilization in which he obtained only slight, temporary improvement in hearing. He believed that best results were obtained in early cases and that mobilization was not effective after complete ankylosis. Feraci[13] reported some success with mobilization. Blake,[14,15,16] Jack,[17,18] and Burnett,[19] in America, tried mobilization but eventually turned to stapedectomy performed through myringotomy incisions. The subject of oval window surgery disappeared from the literature after 1900. The following statement by Sourdille[20] is representative of the thinking that led to the abandonment of this type of surgical procedure:

The footplate of the stapes is so fixed by an osseous process and its crura so wedged in by the borders of the deformed oval window that extraction of the ossicle is practically impossible. If one exerts traction on the crura, they are certain

to be fractured and there is no other way of raising the footplate. Besides, be assured that even if this could be done, the large communication established between the hole opened by the ablatum of the tympanus and the labyrinth will permit infection to enter and will thus lead to inevitable total deafness. It was this simple conception which led in 1900 to an official condemnation of the operation which was so severe that we are still influenced by it. 1937.

The direct route to the inner ear having been abandoned, surgeons turned to fistulation of the horizontal semicircular canal. Jenkins,[21] Barany,[22] and Holmgren[23,24,25] contributed to basic pioneering in this field. Holmgren introduced microscope and magnifying glass to otosclerosis surgery. Sourdille[26,20] developed a three-stage tympanolabyrinthopexy, which he reported at the New York Academy of Medicine, and Lempert,[27] in 1938, reported his practical one-stage procedure which with modifications, came to be the keystone of surgery for otosclerosis.

In 1946, Lempert[28] reported a technique for detaching the tympanic membrane from its annular attachments as a surgical approach to the middle ear for tympanosympathectomy.

In 1952, Rosen,[1] adapting Lempert's approach to the middle ear to verify the diagnosis of otosclerosis prior to fenestration, accidentally mobilized the stapes. The patient's improvement in hearing was dramatic and long lasting.

This inspired Rosen[2] to work out a stapes mobilization technique. This technique has been modified and remodified by many authors,[29,30,31,32,33] and is now used by nearly all otologists before they consider the fenestration operation in cases of otosclerosis.

At the outset of this investigation, the literature was completely silent about combining the stapes mobilization and fenestration procedures. That Lempert[34] had spoken of such a procedure was known to me; however, a copy of his paper, "Evolutionary Progress in the Surgery of Middle Ear Deafness," presented in April, 1955, before the New York Academy of Medicine, was not available from the Academy or from

Dr. Lempert,[35] who indicated, upon inquiry, that he did not do the stapes mobilization operation. More recently information has become available concerning this practice used by a few otologists in America and a number abroad, where it appears to be more popular.

Tato[36] (Argentina) states that he resorts to fenestration immediately if mobilization fails after every effort has been made, and that in cases of apparent mobilization with doubtful hearing gain he sometimes resorts to fenestration, according to personal impressions.

Wullstein[37] (Germany) frequently lists patients for stapes mobilization—possible fenestration, and in case of failure proceeds with fenestration. He makes the window in the knee of the external horizontal semicircular canal and covers it with a free graft.

Portmann[38] (France) reports that for stapes mobilizations he prefers a retro or suprameatal approach, with adequate removal of overhang for exposure of the round window. He dissects a long flap. He believes that this approach gives best conditions for working on the stapes and windows. He says, "In case of failure to mobilize the stapes and, if the round window is normal, it allows the opening of the oval window by resection of the affected footplate, or the possibility of immediately completing the operation by classical fenestration."

Cebrian[39] (Spain) says that, "When both crura are broken, the stapes or the incudostapedial articulation is luxated, or a noticeable hearing gain is not obtained, we immediately perform a fenestration so as to spare the patient a second operation." Cebrian[40] places great emphasis upon observation of the round window and its membrane as a criterion of success. He stresses that if the membrane or its light reflex can be seen to move when the stapes is palated, the stapes must surely have been mobilized.

In Canada, Smith[41] has combined the procedures. The only fault he and his associates have found with the combination procedure is the time consumed in shifting from one opera-

tion to the other. He believes that if the stapes appears to have been mobilized then one should not proceed with a fenestration regardless of audiologic findings.

In the United States, Lindsay[42] has listed five cases to be done as combined procedures if the stapes fail to mobilize. In two of them, the stapes mobilized and the procedures were discontinued. In two cases mobilization apparently was not achieved, and fenestrations were immediately performed. In the other case the stapes appeared to have mobilized satisfactorily, but the audiograms failed to indicate satisfactory improvement in hearing. This confusion caused him to abandon the idea of the combined procedure.

In the United States, also, Knight[43] has performed more than 39 immediate fenestrations after unsuccessful stapes mobilizations. He says that by continuing the operation he has not had the problem of the disappointed patient after unsuccessful stapes mobilization. Study of the footplate and oval window in these cases after removal of the bridge and a partial ossiculectomy has revealed that usually the crura were fractured and, even with excellent exposure, it was impossible to mobilize the footplate or to create a fracture across it.

Farrior[44,45] schedules cases having little chance for success with stapes mobilizations as exploratory tympanotomy and fenestration. If he finds a small otosclerotic focus with easy mobilization, he stops. If there is a large growth of bone which would necessitate a great deal of manipulation after which secondary closure would be likely, he proceeds with fenestration. This he accomplishes by making the transmeatal portion of the regular fenestration incision, cutting a long flap, then doing the exploratory tympanotomy. If the stapes mobilization fails, he makes the complete incisions and proceeds with the fenestration.

PART I.

MATERIAL AND METHODS.

For nine months (December 15, 1955, to September 15, 1956) all patients who were considered good candidates for

either a stapes mobilization operation or fenestration operation were given a choice. They could have the stapes mobilization operation by itself with the understanding that a fenestration would be done after the healing was complete, if the mobilization failed; or they could have the stapes mobilization procedure with preparation made so that, in event of failure, general anesthetic would be immediately administered and fenestration immediately performed.

TECHNIQUE.

Premedication: Chlorpromazine hydrochloride (Thorazine) 25 mg. is given intramuscularly 45 minutes preoperatively. Another 25 mg. ampule is sent to the operating room with the patient in anticipation of severe anxiety, or the occasional vertigo or nausea accompanying mobilization. Chlorpromazine hydrochloride (Thorazine) tends to control anxiety without dulling the patient's senses to the point of uncooperativeness.

With the patient under local two per cent lidocaine (xylocaine) hydrochloride and epinephrine anesthesia, a regular endaural incision is made. A small amount of periostium is elevated posteriorly, and the outer thickened portion of the skin of the posterior external canal is trimmed. A mastoid retractor is then placed and the wound opened widely. A long flap is fashioned from the posterior skin of the canal from 12 to 6 (inferiorly) instead of from 9 (anteriorly) to 6 (inferiorly) as done regularly in the fenestration, to avoid an excess of redundant flap in the canal while doing the stapes mobilization. The flap is lifted from the canal wall with the periosteal elevator and folded forward (see Fig. 1). The posterior half of the drum is detached. The detachment is not carried forward to nine o'clock anteriorly, as in the original Rosen technique, lest in rotating the flap into place following a fenestration one will put tension on the lower free portion of the drum, thus preventing its healing back to its inferior attachment, and thus producing perforation (combined technique Case 1), which is difficult to correct. Bone is curetted posteriorly-superiorly, if necessary, for adequate visualization of the incudostapedial joint, stapedius

tendon, and stapes. In all except two of these cases, the original Rosen[2] technique was employed for actual mobilization of the stapes.

If the mobilization is successful, the long flap is replaced and packed in place lightly with cotton balls over surgical rayon.

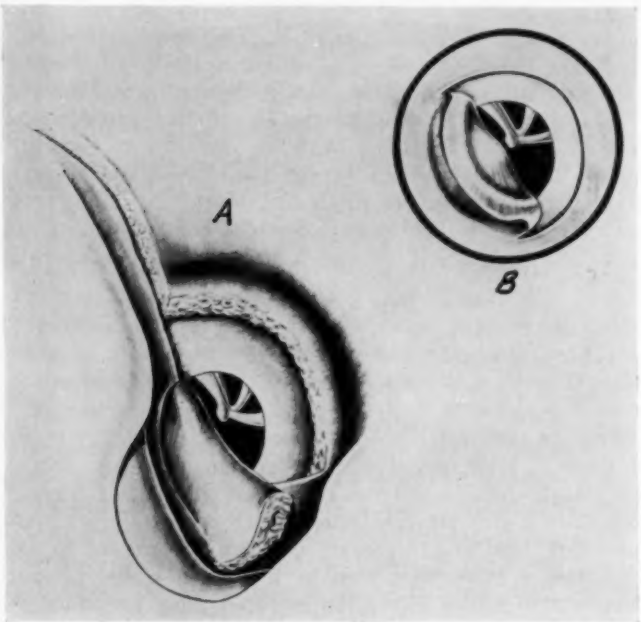

Fig. 1—A. Incision used for stapes mobilization—possible fenestration procedure. B. Incision used for stapes mobilization only.

If the mobilization is unsuccessful the incision in enlarged, the cortex is removed with the bur from the zygomatic route to the sinodural angle, and the usual fenestration is carried out, the flap having been previously dissected and fashioned.

Criteria for success or failure of stapes consisted of visual and tactile observations of the stapes, spoken voice, and surg-

ical audiometry. During this first period, various techniques of audiometry were tried in the struggle to find an infallible method. When the mobilization result was questionable, fenestration was always deferred. The problem of establishing a criterion will be taken up later under a separate heading.

RESULTS.

Twenty-three patients were listed as stapes mobilization—possible fenestration during this nine-month period. On the table, six cases appeared to be obvious failures, and immediate fenestrations were performed. In 17 cases, the stapes mobilization appeared to be either successful or questionably successful, and immediate fenestration was not carried out. Four of this group were considered to be failures at the three-week postoperative audiometric check. One appeared to be successful at three weeks, but had dropped back to the preoperative level in five months. Three of these five failures submitted to later fenestrations carried out two to seven months postoperatively. All were successful. The previous long flap mobilization procedure did not interfere with subsequent fenestration in any way. Cases done as a combined procedure are reported herewith.

REPORTS OF CASES.

Case 1. A white woman, age 55 years, was first seen in June, 1953, for treatment of bilateral external otitis resulting from the use of a hearing aid. Inquiry into her hearing problem revealed that she had had a bilateral, progressive hearing loss accompanied by tinnitus for some 25 years.

Physical examination of the ears, nose and throat was negative except for mild external otitis, which responded quickly to treatment. Tuning fork tests and audiograms revealed a bilateral hearing loss averaging 62 decibels on the left and 60 decibels on the right in the speech frequencies. Bone conduction audiograms indicated that the patient was a borderline Class A candidate for a fenestration on the left, and Class C on the right. Medical examination and laboratory tests, as well as roentgenograms of the mastoids were negative. A fenestration operation on the left was recommended but declined; however, two-and-one-half years later, in January of 1956, the patient agreed to a stapes mobilization operation, to be followed immediately by a fenestration in event of failure.

Operation: On January 17, 1956, with the patient under local anesthesia, an endaural incision was made, and the usual fenestration flap was cut and elevated down to the annulus flibrosis posteriorly. The posterior half of the tympanic membrane was then lifted out of its sulcus and folded forward to expose the middle ear. The incudostapedial joint was found to be unusually far anteriorly so that it was impossible to place

the Rosen mobilizer properly on the neck of the stapes to make posterior pressure. The crura were fractured eventually without improvement in hearing after an attempt to mobilize the stapes by anterior pressure at the neck.

Thiopental sodium (Pentothal) was administered intravenously, an intratracheal tube was inserted, and from this point a fenestration operation was performed in the usual manner. The window was made by the cupola technique of Lempert, and the flap was invaginated into the window. In rotating the flap after this type of dissection (drum separated to or past six o'clock (anteriorly), the posterior-inferior drum margin tends to stretch fairly tightly and to pull away from the tympanic sulcus, so as to produce (as in this case) a perforation difficult to heal.

Postoperative recovery was uneventful. Secondary split thickness graft from the inside of the upper arm was laid into the cavity on healthy granulations on the twelfth postoperative day and healing was prompt. As the cavity dried out and healed, a wedge-shaped posterior-inferior perforation was seen to exist. This resulted in failure to obtain serviceable hearing.

On April 13, 1956, three months after the fenestration on the left, a stapes mobilization was attempted on the right. It also failed because of the anterior placement of the stapes, as on the left, which made manipulation by the Rosen technique impossible.*

Sporadic attempts to close the perforation in the left failed because the patient was unable to return regularly for treatment.

In January, 1957, one year after her fenestration operation, the perforation was grafted by the method of Wright.[46] The cavity was exposed by incising through the old scar superiorly and spreading the meatus with a self-retaining mastoid retractor. With this exposure, the epithelium was removed about the perforation for a distance of 5-6 mm., with the angled chalazion curettes. A small split thickness graft was removed from the non-hair-bearing skin of the mastoid process, laid over the perforation and made to overlap the perforation by 6-7 mm. in all directions. The graft was held in position by small cotton balls placed against it lightly without pressure.

The patient left the hospital on the second postoperative day. The cotton balls and sutures were removed on the fourth day. The hearing level now averages 22 db. in the speech frequencies two months postoperatively. The cavity is dry and the tympanic membrane is intact.

Case 2. A white woman, aged 48 years, first seen in January, 1956, complained of bilateral deafness of about twenty years' duration. She denied pain, discharge or vertigo, but said that she had a roaring tinnitus most of the time. Her hearing defect had at first been rapidly progressive, but had not seemed to change in recent years.

Physical examination was not remarkable. Tuning fork tests and audiograms revealed a bilateral conductive hearing loss averaging 55 db. on the right side and 57 db. on the left. Bone conduction audiograms indicated that the right ear fell into Class B, and the left Class A for fenestration. Medical examination, laboratory tests and roentgenograms of the mastoids were normal.

The right, or poorer ear, was selected for operation. An immediate fenestration was recommended if a stapes mobilization failed to improve hearing on the table.

*This stapes was successfully mobilized recently by transincudal pressure with the Derlacki mobilizer.

On February 1, 1956, with the patient under local anesthesia, an endaural incision was made and a long flap elevated downward to the tympanic membrane. The posterior half of the membrane was lifted away and folded forward; the incudostapedial joint was thus nicely exposed.

The Rosen mobilizer was placed anteriorly on the neck of the stapes and posterior pressure was made. This resulted in fracture of the crura without evidence of increased hearing. The patient was then given thiopental sodium (Pentothal) by vein and intubated. A fenestration procedure was done by the cupola technique of Lempert. When an attempt was made to fit the flap before completing the window, it became evident that, in anticipation of a successful stapes mobilization and in an attempt to avoid the impediment of a redundant flap in the way for the mobilization, the flap had been cut too short to cover the window properly; therefore, a split thickness graft was taken from the inside of the thigh with an electric dermatone. It was placed over the window and the area ordinarily covered by the tympanomeatal flap. It was placed so as to cover the drum completely. Two other portions were perforated and placed superiorly and posteriorly so that the complete cavity was covered by skin. The graft was invaginated into the window and held by a small piece of cotton. The cavity was packed with cellulose sponges and vaseline gauze over rayon strips.

The outer dressing was removed on the fifth day, as were the vaseline gauze and cellulose sponges. The rayon strips and cotton were removed on the tenth day.

Although the grafts seemed to take and the cavity became dry, in time in nearly all the cavity, the grafts have been replaced by mucus-producing epithelium. The central graft covering the window has remained. A posterior-inferior perforation of the drum has remained as in Case 1.

Hearing improved to a 38 db. average in the speech frequencies, and the improvement has remained.

Case 3. A white woman, aged 32 years, was first seen in December, 1952, complaining of gradually progressive bilateral hearing loss associated with roaring tinnitus on the left. She said that this hearing deterioration had begun about 18 years previously. She heard better in noisy rather than in quiet places.

Physical examination was not remarkable. Tuning fork tests and audiograms revealed a bilateral conductive deafness averaging 55 db. on the right and 60 db. on the left in the speech frequencies. Bone conduction audiograms indicated that the right ear should be considered Class A for fenestration and the left a Class B for fenestration. Medical examination, routine laboratory tests and roentgenograms of the mastoids were normal.

A fenestration on the right was recommended but never accepted. The patient returned in December, 1955, however, requesting a stapes mobilization and consented to a combined procedure if the stapes mobilization failed.

On February 3, 1956, with the patient under local anesthesia, an endaural incision was made and a self-retaining mastoid retractor was placed. The long fenestration flap was elevated down to the tympanic membrane, which was in turn lifted from its sulcus from 12 to 6 o'clock posteriorly. The Rosen mobilizer was placed on the neck of the stapes anteriorly and pulsating pressure made posteriorly. The crura fractured. There was no subjective improvement in hearing. A fenestration was then carried out without incident while the patient was under general anesthesia. Postoperative recovery was uneventful.

Secondary skin grafts were laid into the cavity on clean granulations on the eighteenth day after operation. Healing was satisfactory. Hearing has improved and been maintained at the 25 decibel level in the speech frequencies.

Case 4. A white woman, age 50 years, first seen on March 17, 1956, complained of hearing loss for 25 years. She said that the loss had been progressive and accompanied by occasional roaring tinnitus, and that she had worn a hearing aid for two years.

Physical examination of the ears, nose and throat was normal. Tuning fork tests and audiograms revealed a conductive deafness of 55 db. in the speech frequencies on the right and 48 db. on the left. Bone conduction audiograms indicated that she would be a Class A candidate for fenestration in either ear. Discrimination scores were 84 per cent right and 88 per cent left.

A stapes mobilization was recommended on the right (poorer ear) to be followed immediately by a fenestration in case of failure.

On May 19, 1956, while the patient was under local anesthesia, an endaural incision was made and fenestration flap was elevated. The posterior half of the membrane was freed and folded forward. The incudostapedial joint was well visualized after curettage posterosuperiorly. The mobilizer was placed anteriorly on the neck of the stapes. Posterior pressure produced motion of the head posteriorly, but neither voice response or pure tone audiometry in the speech frequencies indicated any improvement in hearing. A fenestration was, therefore, carried out with the patient under general anesthesia. It was without unusual incident, as in the previous cases, and postoperative recovery was uneventful. The cavity was secondarily grafted with split thickness grafts from the inner surface of the arm on the sixteenth day. The cavity healed quickly. Hearing improved to a 20 decibel average loss in the speech frequencies, and the improvement has been maintained.

Cases 5 and 6 are in no way essentially different from Case 4. In both cases, the Rosen maneuver resulted in fracture of both crura. Voice tests, as well as pure tone audiometry, indicated that no improvement in hearing had been obtained. Fenestrations were done, the cavities secondarily skin grafted, and anticipated improvements in hearing were obtained and have been held.

No loss of cochlear function in any of these six cases was observed in postoperative bone conduction audiograms.

PART II.

THE SPECIAL PROBLEM OF ESTABLISHING AND EVALUATING CRITERIA OF SUCCESS OR FAILURE OF STAPES MOBILIZATION AT THE TIME OF SURGERY.

Up to this point, a combined procedure apparently had no major disadvantages if one erred on the side of safety in

not going ahead with the secondary fenestration procedure if the least possibility of a successful mobilization existed. Technique had ceased to be a problem.

Discussions at the meeting of the American Academy of Ophthalmology and Otolaryngology in October, 1956, (House[47] and Kos[48]) brought out a possible situation that I had not encountered in my practice. What about the patient who apparently has no improvement at the time of mobilization but later, up to three months, demonstrates a strikingly successful result? These "sleepers" could be unnecessarily subjected to fenestration by combining the two procedures unless more accurate means of evaluating results on the table could be found.

Baron[49] also had spoken out against the combined procedure. He presented one case in which the crura were fractured, but the footplate was mobilized. Surgical audiometry immediately after the procedure showed a very poor result; the hearing was worse. Two weeks postoperatively an audiogram revealed that the air-bone gap had been closed. On this basis, Baron concluded, "The evidence here is clear that one cannot tell at the time of surgery whether or not the mobilization is successful." He believed that fenestration should always be deferred until results of stapes mobilization can be properly evaluated.

I abandoned the combined procedure pending further evaluation of this new problem, which I had not recognized.

Whether I had done unnecessary fenestrations, or could possibly do them in my present mode of practice and, if so, what I might do to prevent such errors became a pressing issue; therefore, I decided on two studies:

1. I would run a series of cases of stapes mobilization only. At the time of operation, I would apply all criteria and judgment at my disposal. On this basis, I would decide whether or not a fenestration should have been done in each case had it been scheduled as a combined procedure. Then I would compare these on-the-table judgments with postoperative

audiograms. I would try to correlate percentage of on-the-table errors in judgment with criteria applied.

2. I would question other otologists about criteria of success and the incidence of apparent failures on the table resulting as successes postoperatively.

THE DIRECT VISION TECHNIQUE IN SURGICAL AUDIOMETRY.

Early in my experience with surgical audiometry, I had noticed that the windows would not infrequently fill with blood during the long period of testing when the middle ear was hidden from vision by a sterile towel and audiometer receiver. Distrusting the audiograms obtained by this means, I devised a "direct vision" technique of "comparative surgical audiometry."

An A.D.C. portable audiometer was used. The circular rubber ear mold was removed from the receiver or earphone. A stethoscope bell with a detachable 18-inch rubber tube was placed firmly against the center of the face of the receiver, and the rubber mold was then replaced tightly supporting the stethoscope in position firmly against the ear piece (see Fig. 2). The rubber tube was kept sterile and attached to the bell by a Luer-Lok only when testing. The stethoscope bell and rubber tube guided the sound directly to the ear speculum, which remained in place.

The 10-15 db. dampening effect of the rubber tube on the sound was such that audiometric measurements done in this way could not be compared accurately with preoperative audiograms, and it was used only to compare the second (drum off premobilization stage) with the third (drum off postmobilization stage) and was, therefore, referred to as "comparative audiometry" only. Between each change in intensity of each frequency, the tube could be removed from the speculum and the windows examined, thus the term "direct vision" audiometry. This method also had the advantage of cutting out extraneous noises in the operating suite during testing.

Goodhill and Holcomb[50] pointed out that, "Discrete frequency characteristics in surgical audiometry are not as

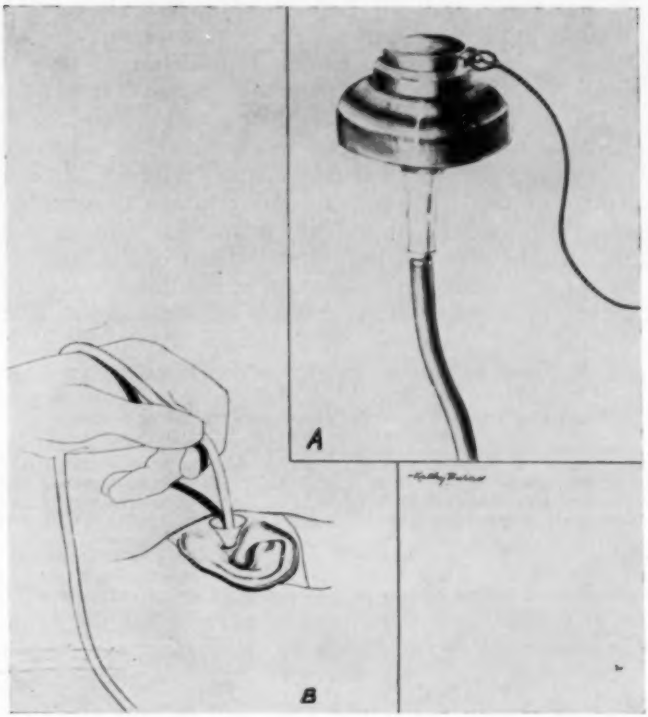

Fig. 2—A. Audiometer receiver with stethoscope bell and tube firmly fixed to face. B. End of rubber tube placed in ear speculum during testing.

important in guidance as the average amplitude of response." They used the Fletcher[51] formula for converting pure tone threshold to an equivalent speech reception threshold. This is done by averaging the two best responses of the three (500, 1000 and 2000) frequencies tested for an SRT, or single "figure of merit" for comparison of steps in the surgical audiometric procedure. The analysis of Goodhill and Holcomb[50] of 20 typical successful stapes mobilizations showed a gain of 5 db. at 500, 10 db. at 1000 and 10 db. at 2000 between stage 2 and 3 (the critical stage); therefore, I adopted the routine of "direct vision" audiometry, doing pure tone thresh-

olds only twice; once just before mobilization and again immediately after mobilization. The tests were repeated after successive mobilization attempts if necessary. Only the frequencies 500, 1000 and 2000 were tested. If responses for the second audiogram were 10 db. better than the first in any two frequencies, the case was recorded as "successful." Any less improvement was recorded as "failure." Since the adoption of this technique and this criterion of success, 65 stapes mobilizations have been performed. No combined procedures have been done, but at the time of the three-week postoperative audiogram and again at the three-month check I asked: On the basis of the criterion employed and its results

TABLE I.

Results of Direct Vision Technique of Surgical Audiometry in 65 Consecutive Cases of Stapes Mobilization.

Inapplicable for various reasons	9, or approximately	13.8%
Accurately predicted success in	35, or approximately	53.8%
Accurately predicted failure in	10, or approximately	15.4%
Inaccurately predicted success in	7, or approximately which were failures at three-month check.	10.8%
Inaccurately predicted failure in	4, or approximately which were successful at three-month check.	6.2%
	65	100.0%

at the time of operation, could an unnecessary fenestration have been performed?

RESULTS OBTAINED BY USING DIRECT VISION AUDIOMETRY AS A CRITERION.

An attempt was made to use the direct vision technique of surgical audiometry in 65 consecutive patients (see Table I) in whom stapes mobilizations were done between July 1, 1956, and June 15, 1957. In four patients, or 6.2 per cent, this criterion inaccurately indicated failures at the time of surgery but later audiometric tests (three months postoperative) indicated that the operations had been successful. Success

was defined as an average 10 db. or more gain in the speech frequencies over the preoperative average. In these patients unnecessary fenestrations could have been performed if they had been scheduled for combined procedures and no other criteria had been relied upon. In all four patients, visual and tactile impressions, as well as response to voice tests, indicated that mobilization of the stapes had been accomplished. This criterion accurately indicated success in 35 patients or 53.8 per cent, and accurately indicated failure in 10 patients or 15.4 per cent. It inaccurately predicted success in seven patients who showed no improvement at the three-month check.

Audiometry could not be carried out in 9 of the 65 patients (13.8 per cent) for the following reasons:

1. Oversedation in two patients.

2. Excess bleeding in one hypertensive patient in whom adrenalin could not be used for hemostasis.

3. Audiometer out of repair when two patients were operated on.

4. In one patient, the stapes was inadvertently mobilized by transincudal pressure in obtaining proper exposure by curettage.

5. Three patients were so deaf that the 10-15 decibel dampening effect of the tube on the sound transmitted through it made premobilization audiometry impossible by the "direct vision" technique.

THE QUESTIONNAIRE.

In May, 1957, while the foregoing data were being accumulated, an attempt was made to find out how other otologists were solving these problems of surgical audiometry, criteria of success, and the problem of the patient with apparent failure who later gained hearing. I wanted to see also whether there existed any particular criterion or method of audiometry that uniformly and accurately predicted success or failure on the table in the hands of more than one otologist.

Letters were sent to 88 otolaryngologists known to me personally to be doing otosclerosis surgery or assumed to be doing this surgery by virtue of membership in the Otosclerosis Study Group. A brief explanation of the problem was given, and the following information was requested:

1. In how many, or in approximately what percentage of your stapes mobilizations have you observed late hearing improvement in cases which were apparently failures at the time of operation?

2. What criteria were employed at the time of operation to decide whether the procedures were or were not successful?

3. Any additional comment you care to make concerning a combined stapes mobilization fenestration procedure would be greatly appreciated.

More or less complete replies were received from 50 otologists. The percentage of apparent failures improving later was given anywhere from 0 per cent to 42 per cent. The median was 7.5 per cent of total cases. Most percentages given were approximations rather than actual counts.

As for criteria, 26 used some form of pure tone audiometry, and 10 of them specified four-stage audiometry. Eleven indicated that voice or speech tests were employed with the audiometry. Six used voice tests only.

Four stressed the use of tuning forks, and two laid heavy emphasis upon reversal of the Rinné test as a criterion.

One surgeon ingeniously and uniquely uses a Sorenson rotary electric vacuum pump which has a low hum. Before the operation, this surgeon asks the patient if he can hear the hum of the machine and repeats the question after the stapes is mobilized. All of this otologist's patients in whom mobilization was successful have been able to hear the pump. He has had no late successes which were thought to be failures on the table.

Four stressed visualization of the footplate and round window membrane.

No generalizations were possible about criteria, but three points were of interest: *1.* The four otologists who stressed visualization of the footplate and round window reported considerably less than average errors in prognosis on the table; *2.* It may be quite significant that the otologist who uses the pattern of sound coming from a vacuum pump reported no failures on the table who have later gained hearing; *3.* Of the two otologists stressing reversal of the Rinné test, one reported 2 per cent failures on the table—later hearing—the other reported "very few."

Additional comment on the overall subject of the combined procedure was very interesting and raised many interesting thoughts:

Enthusiastic about the combined procedure	3
Adamantly against	3
Generally favorable to the idea	6
Skeptical because of specific problems that came to mind	18
Interested but no special feeling pro or con	20

One otologist very significantly pointed out that since simple stapes mobilizations have been known to produce cochlear damage, it would be worse to attack the labyrinth twice at one sitting.

Three otologists regularly schedule cases as stapes mobilization possible fenestration.

One objected to the combined procedure because it defeats the simplicity which characterizes the stapes mobilization procedure.

Two felt that a combined procedure would solve the problem of the stapes mobilization failures who will not return for fenestration.

One said that the combined procedure "saves the patient a gamble."

Two expressed fear that the flap might not fit.

Four objected on the basis of the difficult psychological and

economic problems involved in preparing a patient for a major or a minor procedure with subsequent long or short hospital stay.

Three objected on the basis of the difference in premedication for two procedures; that is, a patient premedicated only for a stapes mobilization is not prepared for fenestration; also, some operators sedate stapes mobilization patients so heavily that they cannot reliably respond to hearing tests upon which the decision to fenestrate may be based.

One objected that unnoticed blood in the middle ear might interfere with the accuracy of the audiograms.

Three suggested parts of the following thought: that footplate perforation, stapedectomy, and other such surgical attacks upon the oval window would not only render the hearing tests unreliable as far as predicting ultimate success of the operation, but also supplant the classical fenestration operation as a secondary procedure in case of failure of simple mobilization.

One objected to excess bleeding and unwieldiness of the large flap.

Under additional comments, the dangers of stapes mobilization were stressed. Two otologists knew collectively of four dead labyrinths and one fatal meningitis resulting from stapes mobilization operations.

CONCLUSIONS.

The problem of technique, in combining the stapes mobilization and fenestration procedures if the former fails, lends itself to simple solution. It may be considered practical.

The special problem of establishing adequate criteria upon which to base the decision to proceed with the fenestration appears to be surmountable. With adequate magnification, illumination, and exposure combined with painstaking direct vision audiometric control, very few patients submitting themselves to such a stapes mobilization-possible fenestration procedure would be unnecessarily fenestrated. Is the fenes-

tration so formidable or destructive that its performance in this small percentage should contra-indicate an otherwise reasonable and advantageous system of practice? At this point, no strong contra-indication to the combined procedure seems to exist. The choice of procedure evolves as one of personal preference.

In patients in whom fenestration of the oval window, chiseling, or other excess trauma to the footplate is anticipated, a fenestration should not be considered for fear that two inflammation-producing assaults upon the labyrinth might result in loss of cochlear function. It is because of the increasing popularity of these footplate procedures that the combined procedure is not likely to come into general use.

DISCUSSION.

When one considers whether to practice separate stapes mobilization and fenestration procedures or the combined procedure, a host of major as well as minor advantages and disadvantages of the two concepts becloud one's judgment. The individual otologist must place them in proper perspective in making his own decision. Having temporarily discontinued practicing the combined procedure for approximately one year while collecting data for a part of this study, I find it difficult to decide whether or not to resume the procedure.

The following factors must be evaluated in making a decision:

1. Failure to hear after stapes mobilization has a bad psychological effect on the patient. Failure occasionally may result in bitterness, but more often in loss of confidence in surgery as a means of rehabilitation. The patient then is deprived of having serviceable hearing ultimately restored by returning for fenestration or stapes mobilization of the opposite ear. Even in the patient who plans to go ahead with further surgery after a stapes mobilization failure, the anxiety and waiting between operations in undesirable and is avoided by the combined procedure.

2. Cost to the patient in time and money is increased by

two hospital admissions and two operating room charges. The combined procedure is more economical for patients requiring two operations.

3. The length of time consumed in performing a combined operation is very great, especially if a number of attempts are made to mobilize the stapes and each attempt is followed by an audiometric check. A surgeon may very well be exhausted by the time he must perform the most critical part of the fenestration operation. Great inconvenience to all persons concerned with the use of the operating room is caused by scheduling patients for combined procedures, because the time involved is unpredictable; it may range from a few minutes to all morning. If there is any possibility that a patient scheduled as combined will require fenestration, the surgeon can scarcely list more than one patient in a morning. Of course, the problem created is no greater than that frequently encountered in cancer surgery in scheduling a patient for biopsy and possible radical lymph node dissections.

4. Sedation must, to a degree, be sacrificed if the patient is to be alert and cooperative enough to respond accurately to audiometric examination on the table. I suspect that many prognoses of failure made on the table and later refuted were the result of heavy sedation. The practice of giving only 25 mg. of chlorpromazine hydrochloride intramuscularly before operation had seemed to allay the patient's tensions but leave the patient alert enough to be checked audiometrically. If considerable nausea or vertigo occur or the patient becomes tense, another 25 mg. of chlorpromazine hydrochloride may be given intramuscularly or intravenously.

I have used 10 mg. of prochlorperazine (Compazine) recently instead of 25 mg. of chlorpromazine hydrochloride (Thorazine). The pharmacologic action is essentially the same, but the danger of the occasional jaundice following the use of even small doses of chlorpromazine hydrochloride is avoided.

5. The increasing popularity of footplate perforation and stapedectomy in the rapidly changing scene of otologic surg-

ery has affected and will have further impact upon the concept of the combined stapes mobilization and fenestration procedure:

a. Perforation of the footplate[31,32] may result in improved hearing on the table with later loss, and may thus cloud the criteria of success at the time of operation. This situation could not result in unnecessary fenestration, however, because the error would encourage failure to do a needed fenestration.

b. If simple stapes mobilization has been known to produce dead labyrinths and fenestrations only have been known to produce dead labyrinths, then combining these procedures might be expected to increase the number of these catastrophes. The combined procedure, however, should be safe in cases in which the footplate is heavily overgrown and surgical attack is not attempted, or where it is attempted and found to be futile. Good magnification and exposure are most important.

c. The practice of removing the stapes, as suggested by Portmann and Claverie,[38] Rambo,[54] Wullstein,[54] and Shea,[54] could conceivably result in all manipulations being confined to the oval window in the future. If stapes mobilization fails, the stapes is removed *in toto*. Then the stapes is replaced with "plastic substitution" (Wullstein, Shea), or the ear drum is placed directly over the opened oval window (Rambo), or a portion of a previously fashioned large tympanomeatal flap is invaginated down into the middle ear over the opened oval window (Portmann and Claverie). The general adoption of this concept would eliminate completely the use of a combined stapes mobilization, fenestra-nov-ovalis operation.

6. Unfortunately all patients on whom combined procedures are anticipated must have regular endaural incisions which prove to be unnecessary in the majority of patients who ordinarily require only stapes mobilization. Thus the patient whose mobilization is successful is penalized by the necessity of a mastoid dressing, extra trauma, bleeding and pain.

7. The fashioning of a long tympanomeatal flap prior to

stapes mobilization has advantages and disadvantages. In a narrow canal, the long flap may be redundant and awkward, and may to some degree obstruct vision. On the other hand, with this type of preparation, bone may be removed without difficulty for better exposure. I, personally, feel that visualization and maneuverability of instruments are easier than through the speculum as employed in the regular technique. This freedom of motion is especially helpful in curetting the overhang posterio-superiorly for better exposure of the incudostapedial joint and stapedius tendon.

a. In an attempt to avoid the long redundant flap, one is tempted to cut it too short to cover the fenestra adequately (Case 2), and one must then use a free graft. This pitfall is solved by experience. Knight[43] has not encountered this difficulty in more than 39 operations.

b. Another pitfall in technique is inadvertently creating a postoperative posterio-inferior perforation of the drum. If the drum is detached inferiorly anywhere nearly as far forward as Rosen[1,2] described in his original technique, the inferior part will pull away from the bone inferiorly when the flap is rotated. This defect is not obvious at the time, but it is apparent postoperatively (see Case 1).

c. An advantage of the longer flap is evident when an inadvertent tear in the posterior part of the drum occurs. Sliding the long flap medially provides adequate extra skin so that the raw edges of the tear may be overlapped.

8. Those who, after failure to mobilize the stapes, prefer to attempt the opposite ear and again re-enter the first ear for revision prior to fenestration, will find little use for a combined procedure. Either the surgeon will eventually succeed in obtaining hearing by stapes mobilization only, or the patients will give up.

I do not believe that the "direct vision" technique of surgical audiometry, or any form of audiometry, is a panacea for determining success or failure of a stapes mobilization at the time of operation. It has, however, in combination with visual and tactile impressions, reduced any margin of error to an insig-

nificant minimum. Though tests performed by this technique would seem to be rendered ineffective by the lack of sound protection for the round window during the test; nevertheless, its relative reliability is supported by clinical observation when it is performed as described.

The recent tendency has been for stapes and oval window procedures to become bolder and consequently more traumatic. Though these new concepts are titilating to the curiosity and inventive genius of otologists few can be considered atraumatic, well controlled, or likely to produce high percentages of long lasting results. The disappointing history of stapes mobilization and oval window surgery in general, prior to the turn of the Century, may well be upon the threshold of repeating itself. Let us hope that some middle ground may be found before these procedures are once again "officially condemned" as in 1900. To the otologist the labyrinth should be held near sacred. If we are to defile it, should it not be by way of the well controlled classical fenestration operation which time has established as a highly successful and relatively safe procedure? The concept of the combined stapes mobilization fenestration procedure offers a safe middle ground if the operator confines his efforts at mobilization to simple maneuvers which produce only minimal trauma. It would offer a safe middle ground for all operators, even those who prefer radical footplate procedures, if only adequate criteria could be developed by which an operator might know with reasonable certainty, in which cases the stapes might mobilize with minimum trauma and in which cases even radical procedures would be useless. Time may give these answers.

SUMMARY.

Occasionally in this country, but more frequently abroad, the stapes mobilization is immediately followed by fenestration in case of failure. This paper attempts to evaluate the practice and the rationale underlying it. A technique developed for such combined procedure is described. Twenty-three consecutive operations listed as stapes mobilization

possible fenestration, of which six were actually performed as combined procedures, are reported.

The special problem of developing criteria to determine at the time of stapes mobilization if fenestration is necessary is discussed. A "direct vision" audiometry technique is described and suggested as one criterion. This criterion was evaluated by applying it at time of operation to 56 stapes mobilizations cases and comparing its prognosis to the final outcome of the cases. This audiometry technique appears to be a reasonably accurate indicator. In this series of 56 cases only four, or 7.1 per cent, would have been unnecessarily fenestrated, even without the aid of visual and tactile impressions and voice tests which belied the audiometric findings in these four cases. A fenestration would have been done on none of these patients.

Analysis of questionnaire responses from 50 otologists failed to reveal an on-the-table criterion for predicting postoperative results of stapes mobilization which was uniformly accurate in the hands of different otologists. Using various combinations of criteria, the median per cent of errors in judgment, which could have resulted in unnecessary fenestrations, had the combined procedure been used was 7.5 per cent.

An attempt is made to review and discuss the many facets of the case for and against the concept of a combined stapes mobilization fenestration. It is concluded that this choice will remain one of personal preference; for there is no strong, firm contra-indication to a combined procedure except when extensive traumatising footplate work has accompanied the stapes mobilization procedure. No loss of cochlear function was observed in postoperative bone conduction audiograms in any of the six patients on whom the combined stapes mobilization fenestration procedure was performed.

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ALUMNI ASSOCIATION OF THE NEW YORK EYE AND EAR INFIRMARY.

The Annual Spring Meeting of the Alumni Association of the New York Eye and Ear Infirmary last April was so well received that it has been decided to expand next year's meeting, which will take place from April 20-23, 1959.

Symposia and lectures on Hearing Rehabilitation, Endoscopy, and Ear Surgery will be conducted. It is also planned to offer refresher courses in Mastoid and Fenestration Surgery and Stapes Mobilization Techniques.

More complete information regarding the meeting will appear in a later issue of THE LARYNGOSCOPE.

DIFFERENTIAL SALPINGOSCOPE; A NEW DEVICE FOR TUBAL AUSCULTATION.*

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New York, N. Y.

After a century of Politzer inflation, word seems to have gotten around to some of the patients when to say "cuckoo" or "kay-kay-kay," but many still have trouble with holding the otoscope tube in their ears. The tube also tends to fall out of the doctor's ear at the moment when he holds the catheter in place with one hand and reaches for the balloon with the other, not having a third hand to catch the dangling ear tube. To obviate such needless aggravations of daily office work, I assembled a more practical device for tubal auscultation (see Fig. 1). It consists of two pairs of binaural ear-pieces similar to a stethoscope. Each ear olive of one set is connected to the homolateral olive of the other set by means of a rubber or plastic tube. The two tubes between the two sets of ear olives are interrupted by one-way stopcocks which allow the occlusion of one or both tubes. One set with the black olives is introduced into the patient's ears; the other with the white olives is placed in the doctor's ears. The device may be ordered from Storz Instrument Co., St. Louis, Mo.

Advantages: *1.* The physician's ears are partly masked for ambient noise, making it easier to concentrate on the tubal sounds; *2.* Binaural auscultation of both tubes, simultaneously or alternatively, gives more audible information on the tubal function; *3.* Simultaneous binaural auscultation provides immediate and impressive comparison of the two tubes. particularly regarding temporal, qualitative or quantitative differences of their patency; *4.* The self-retaining ear sets cannot fall out, no matter how narrow some ear canals may

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be; *5.* No confusion of the patient, and no need for his assistance; therefore, no difficulty in cases of paralysis, tremors, etc.

Disadvantages: The salpingoscope is larger, heavier and more expensive than a simple ear tube.

Inflation of difficult patients: In this connection, I may repeat two modifications of simple tubal inflation which were published in the *Monatsschrift für Ohrenheilkunde*, Vol. 78, p. 146, 1944. As is well-known, some apprehensive or nervous patients frustrate the attempt at tubal inflation by relaxation of the soft palate. Instead of elevating the velum during the

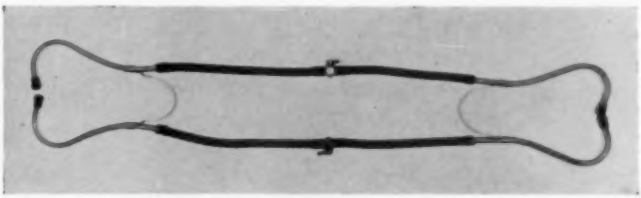

Fig. 1. Differential salpingoscope. Note the two one-way stop-cocks which permit three choices of right monaural, left monaural, and binaural auscultation.

enunciation of certain palatal speech sounds, such as "kay-kay-kay," they maintain it in a flaccid state. In this way, they suddenly present the abnormal articulatory condition of functional rhinolalia aperta. This causes the inflation sounds "kay-kay-kay" to assume a nasal quality, and prevents the very purpose of tubal inflation. Since the inflated air then escapes behind the descended velum into the pharynx, no pressure builds up in the nasopharynx to open and penetrate the Eustachian tubes. Obviously, this irrational action represents the patient's unconscious defense against the remedial maneuver of which he is afraid. Once he has established this conditioned reflex, it is not always easy to re-educate the patient to the correct inflation, and the more complex catheter inflation may be necessary. Needless to state that an apprehensive patient is even more fearful of this instrumental tech-

nique. In such cases I use two physiologic principles to overcome the undesired relaxation of the soft palate.

Inflation during reflex innervation: It is a basic law of nerve physiology that reflex contractions are more resistant to psychogenic disorders than are the conscious and voluntary actions. In hysterical aphonia, for example, the cough reflex

Fig. 2. Inflation during reflex innervation of palate.

remains normal, while voluntary phonation is lost. Similarly, the functional form of open rhinolalia is differentiated from organic palatal paralysis by the preservation of the palatal gag reflex in the former. This fact can be utilized for better tubal inflation.

As Fig. 2 shows, a tongue depressor is held gently against

the soft palate by the left thumb and index finger. This causes the palate to contract and to occlude the nasopharynx. In case of organic paralysis, the same maneuver is used for the passive elevation of the flaccid velum. At the same time, the third left finger occludes the patient's right nostril. The left fourth and fifth fingers find support on the patient's right cheek. Inflation is then effected by the right hand, using a standard Politzer balloon with a rigid tip and detachable nose olive.

Advantages: Prompt and rapid inflation of uncooperative or fearful patients, including children, or in cases of organic palatal paralysis. The patient has nothing to do but to open his mouth.

Disadvantages: Not suitable in the presence of violent gag reflex.

Inflation during continuous articulation: Some patients behave awkwardly when told to say "kay-kay-kay" at the moment of inflation. In such cases it is easier to utilize a fricative sound of longer duration for the elevation of the palate. As is well-known to phonetic specialists, the strength of palatal occlusion is different for the various speech sounds. While it is quite weak for the vowels, particularly for the "ah" sound, the occlusion power is highest for the sibilant sounds; hence, a prolonged unvoiced "sss" usually produces the strongest contraction of the palatal valve. The palatal "k" sound is characterized by a lower pressure. When a patient is instructed to pronounce a prolonged sharp "sss," it is very easy to inflate his tubes during this relatively long period of articulation. His palate remains firmly contracted until he pauses to take a breath, and the physician does not have to concentrate on a precise synchronization of the "kay-kay-kay" with the moment of inflation; further, a sibilant sound tends to produce a very firm palatal occlusion which counteracts a timid patient's escape into the protective state of functional hypoinnervation of his palate.

Advantages: 1. Sibilants produce the strongest palatal contraction which is desirable for effective inflation; *2.* They can be pronounced during a long period of time (10-20 sec.),

so that inflation may be performed without haste; *3.* It is easier for a patient to say a long "sss" than to pronounce "kay-kay-kay" at a precise instant.

Disadvantages: Cannot be used in the very rare case of nasal lisp, a speech disorder due to relaxation of the palate during the articulation of the S-sounds.

THE COLLEGE OF MEDICAL EVANGELISTS.

A course in "Reconstructive Surgery of the Septum and External Nasal Pyramid" will be sponsored by the Departments of Otolaryngology of the College of Medical Evangelists School of Medicine and the University of Southern California School of Medicine, and will be given at White Memorial Hospital, Los Angeles, Calif. The course will begin at 7:00 P.M., January 6, 1959, and end 12:00 noon Friday, January 16. Dr. Maurice Cottle will be the director. All applications should be forwarded to Leland R. House, M.D., 1720 Brooklyn Avenue, Los Angeles 33, Calif.

TRANSITIONAL CELL TYPE SQUAMOUS CELL CARCINOMA OF THE EXTERNAL EAR CANAL.*

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The case of this 65-year-old female is being reported because of an uncommon type of lesion in the external ear canal.

At the age of five years she had scarlet fever and both ears discharged. Following this illness, she had intermittent discharge from the right ear for a period of ten years. She had no further evidence of ear infection until 1957, when following a cold, the right ear began to discharge again. Local treatment gave no relief. The discharge persisted and occasionally was blood-tinged.

At the time of admission to this hospital, in September, 1957, she gave no history of headache, dizziness or pain in the ear. The nose, accessory nasal sinuses, pharynx and larynx were normal. A general physical examination, including X-rays of the chest, elicited no abnormalities.

It was noted that her left ear drum was normal; the right ear canal was filled with a large polyp and some discharge. The fistula test was negative. The regional lymph nodes were not palpable.

X-rays of the mastoids, including tomograms, showed suggestive evidence of some minimal enlargement of the mastoid antrum, as if by a cholesteatoma. There was no evidence of active bone destruction at the inner end of the external ear canal.

Under local anesthesia, with 2 per cent xylocaine infiltration, the polyp in the right ear canal was removed. The details of the drum and middle ear could not be made out. The bleeding was not excessive. Part of the tissue removed was sent to Pathology and part to Bacteriology departments for examination. Bacteriology reported only micrococcal growth.

Following the removal of the polyp from the right ear, vestibular tests were normal in each ear. The hearing tests showed the left ear to be normal. On the right side there was an average loss of 25 db. in the speech range in keeping with a mixed conductive and perceptive deafness.

In view of the pathological diagnosis of transitional cell type carcinoma (see Fig. 1), the case was discussed with the radiotherapist, the radiologist and the pathologist, and it was decided that radical excision should be attempted, followed by radiation therapy.

A radical mastoidectomy through combined endaural and postauricular approaches was carried out on Sept. 28, 1957. The mastoid cells and the middle ear were found to be free from obvious infection and definitely free from growth. The ear drum, though much thickened and scarred, appeared to be intact when it was removed together with ossicles. The growth and ulceration appeared to be limited to the skin of the inner

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third of the external canal, especially of the floor and of the anterior wall. The whole inner four-fifths of the skin of the ear canal was removed. The underlying bone was scraped. There was no sign of the growth invading or being connected with the middle ear. The denuded cavities were covered with skin grafts from the thigh.

Histopathological examination of over 20 pieces of tissue removed from the different parts of the mastoid, the middle ear and the external ear revealed that the growth was confined to the skin of the inner half of

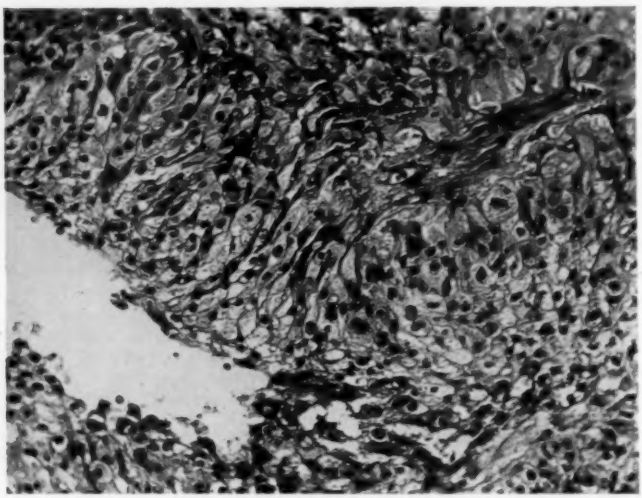

Fig. 1. Transitional cell type carcinoma.

the anterior wall of the external auditory canal. The drum itself was free from evidence of growth.

The wound healed satisfactorily. Radiation treatment was started on Oct. 7, 1957, the ninth postoperative day, and was terminated on Dec. 13, 1957. For the first six weeks, X-ray therapy was given, reaching a dose of 3120 *r* for the center of the petrous pyramid and the middle ear, and skin dose of over 4600 *r* to anterior and posterior fields. There was some skin reaction. The graft had taken well. Further treatment was given with Cobalt 60, using a direct lateral field. An overall maximum tumor dose of 6045 *r* was reached.

The patient was discharged on Dec. 16, 1957. At the time of discharge, the lining of the middle ear and mastoid cavities showed some erythema and moisture but no sign of growth or ulceration. There was no cervical lymph node enlargement.

Carcinoma of the middle ear and external auditory canal

is undoubtedly rare, although a considerable number of cases have been recorded in the literature, and lately increasing numbers are being reported.

Most of the published reports show squamous cell carcinoma to be the most common of all types. Other types, like the basal cell carcinoma, adenocarcinoma, adnexal carcinoma from the sweat and apocrine glands, the lympho-epithelioma, and the transitional cell type carcinoma, have also been reported.

Different proportions have been given in different reports. Spencer[8] (1938) describes seven cases of carcinoma, out of which six were squamous cell, and one basal cell type.

Figi and Hampstead[4] (1943), describing malignant tumors of the middle ear and mastoid, report 38 cases, of which 13 are squamous carcinoma, 11 basal cell carcinoma, five adenocarcinoma, three sarcoma and six hemangio-endothelioma.

Lindahl[6] (1955), reported 16 cases of carcinoma of middle ear and meatus, of which 13 are squamous carcinoma (both poorly differentiated and well differentiated), one adenocarcinoma, one carcinoma-like lympho-epithelioma, one transitional cell carcinoma.

Ellis and Pracy[3] (1954) have published six cases with only one well differentiated squamous carcinoma.

Gisselsson[5] (1952) describes a case of squamous cell carcinoma of the tympanic membrane.

Ash[1] (1956) stated that most cases of adnexal carcinoma are usually diagnosed as adenocarcinoma.

Cancer may originate in the external auditory meatus or middle ear, and it is sometimes difficult to know the exact site of origin, although prognostically it is very significant. According to Miller[7] (1952), cancer of the auricle located within 1 cm. of external auditory meatus is a serious disease, regardless of the histological description. He recommends wide excision for carcinoma of external auditory meatus.

Wahl et al.[9] (1953) classify new growths of the ear as:

1. Extrinsic, in which the auricle, concha, or the external ear canal is involved.

2. Intrinsic, which involves the tympanic membrane, tympanic cavity or mastoid process.

3. Undetermined, origin of which cannot be accurately ascertained.

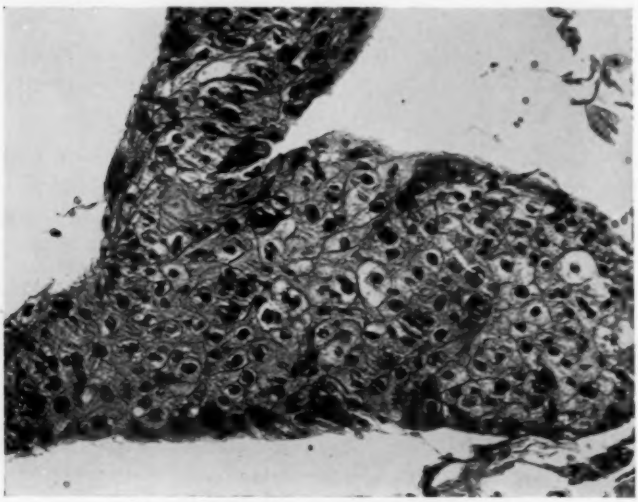

Fig. 2. Squamous character of the tumor.

The malignant neoplasm in the tympanic cavity probably results from a metaplasia of cylindrical cells of the lining membrane to the squamous cell type, or it may have its origin from the glandular elements within the cavity.

The origin of carcinoma in this case was thought to be from the middle ear because of the long history of otitis media; however, at operation, and histopathologically this presumption was found to be incorrect. The tumor involved the deeper part of the external canal without involving the drum or the middle ear cavity. It was diagnosed initially

as transitional cell carcinoma; however, it also showed some areas in which the transitional character of the tumor became more differentiated and showed squamous features (see Fig. 2).

The transitional cell type of squamous cell tumor is one of the undifferentiated types, morphologically. Histologically, it resembles a carcinoma of the urinary tract. The cells have oval, elongated and fairly concentrated nuclei with a relatively small amount of cytoplasm, and have not differentiated into either frankly columnar cells or prickle cells.

This tumor has a typical arrangement of cells in ribbon-like sheets that are looped and folded. It commonly arises from mucous surfaces, but in the present case there was no evidence that it arose from the mucous surface of the middle ear. It arose from the skin of the external canal, which is rather unusual. Most pathologists would probably diagnose this as an undifferentiated type.

The case reported by Lindahl[6] is the only similar one which could be found.

SUMMARY.

A case is reported of transitional cell type of squamous cell carcinoma of the external ear canal without involvement of the middle ear.

A 65-year-old woman had had ear discharge during youth, which recurred during the past year and was occasionally blood-tinged. Widespread excision of the growth and radical mastoidectomy was followed by radiation therapy.

I express my thanks to Dr. W. J. McNally, Dr. E. A. Stuart and Dr. G. C. McMillan for their help in the preparation of this report.

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On December 7 and 8, 1958, the Gruppo Otorinolaryngologica of the Alta Italia will sponsor an International Symposium on Radiology in Otolaryngology under the direction of Prof. Luigi Pietrantoni, Direttore della Clinica dell' Universita de Milan; Prof. Arduimo Ratti, Direttore dell' latitudo di Radiologica dell' Universita de Milan, and Honorary President Prof. Felice Perussia. For further information write the Secretary of the Symposium, Clinica Otorinolaryngologica dell' Universite di Milan, via Commenda 16, Italy.

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